Improvement and the Distribution of Practice

By
Robert Alexander Cummins

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Faculty of Philosophy, Columbia University

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R. A. C.

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Improvement and the Distribution of Practice

INTRODUCTION

It is the purpose of this monograph to report measurements of learning, especially by school children under ordinary classroom conditions, and with special reference to the distribution of time given to practice. The particular comparison made is between (1) a series of practice-periods approximately equal in length, and (2) a series of practice-periods decreasing progressively in length.

Some results obtained by Ebbinghaus ('85, pp. 110 ff.) and Jost's ('97) conclusions that "in the case of two associations of equal strength, but of different ages, a new repetition has a greater value for the older of the two, and that the older association weakens less with disuse in a given time," suggest that the second form of distribution may be the more favorable in the case of forming serial connections with senseless material. General theory also suggests that such a distribution might prevent wasteful overlearning in both initial practice and reviews in the case of a group of bonds which form a limited unit of instruction, as, for example, learning a new word in spelling, a vocabulary in a foreign language, or the anatomy of an animal. Whether such a distribution would prove essentially more favorable in such miscellaneous work as improving penmanship, oral speech, computations of various kinds, and the like, is more problematical.

The experiments to be reported here concern:

A. The learning of French vocabularies by adults.

B. The learning of geographical and historical facts by school children, after the following manner: A brief condensed summary of the facts was studied. The knowledge thus gained was measured by giving the summary, with certain important words omitted, as a completion test.

C. Improvement in single-column addition by school children and by adults.

D. Improvement in short division by school children.

There is thus a range from the definite formation of new bonds from zero strength as in *A*, to the vague general improvement of a function already fairly well established, as in *C* and *D*.

Besides the comparison of the two sorts of distribution of time the experiments with school children furnish valuable data concerning the use of the practice method as a means of instruction, and concerning the relation of initial achievement to improvement.

SECTION I

LEARNING FRENCH VOCABULARIES BY ADULTS

The first study presented, though the last one completed, has to do with the formation of new bonds from zero strength, i. e., the learning of a relatively new thing, as, for example, a new word or object.

THE NATURE OF THE EXPERIMENT

The experiment reported in this chapter was carried out in the fall of 1917, with five graduate students in Teachers College acting as subjects. The group was composed of two women and three men, including the author himself. Three of the subjects (2, 4, and 5) were beginning students in French, and the other two (1 and 3) had studied some French several years ago. These facts will be given due consideration later.

The material learned consisted of French words which were prepared as follows: first, 1,200 ordinary French words were selected and written, together with their English equivalents, on separate slips of paper. These slips were placed in a box and shuffled. The words were then drawn out by chance, arranged in groups of ten, and rewritten. From the entire list thus formed two smaller lists of 150 words each were selected by chance. We first eliminated, however, all those words which were the same in English, or which were suggestive of the English meaning. Each list of 150 words was subdivided into five groups, since by trial it was found that approximately thirty French-English words could be read over in one minute, reading at a convenient rate. Thus it would require just five minutes to read over once an entire list of 150 words.

The following set of instructions, a copy of which was given to each of the subjects, will make clear the conditions of the experiment.

EXPERIMENT IN LEARNING

FRENCH VOCABULARIES

The purpose of the experiment is to compare two different distributions of time in the learning of the vocabulary of a foreign language: *A*—a schedule

in which the study-periods are of equal length, and *B*—a schedule in which the study-periods decrease progressively in length.

DIRECTIONS

1. Be sure you understand all the following directions before beginning the learning of the words.
2. Select a time of the day that is least likely to be interrupted for the next sixteen days, and use the same time of day throughout.
3. Note that there are *two* separate lists, each containing 150 French-English words, and each having its *own* time-schedule.
4. It should require just five minutes to read over one entire list of 150 French-English words, i. e., at the rate of thirty words per minute.
5. When ready to begin, place a timepiece, having a seconds hand, within easy view. Begin, when the seconds hand is at zero, and read over the French-English words, glancing at the timepiece at the end of every group of thirty words, in order to regulate the rate of reading so as to cover just thirty words per minute.
6. Articulate the words under the breath, pronouncing the French words as best you can without undue waste of time.
7. At the end of each *five minutes* (which should also be at the end of the list of 150 words, if you have properly timed the rate), allow a rest of *one minute*, then proceed to go over the entire list again, and so on, until the required amount of time has been put in for that practice-period according to the time-schedule.
8. Having put in the required amount of time with list No. 1, allow two or three minutes' intermission, and then proceed with list No. 2, if the time-schedule calls for any practice on that day, following the same general instructions.
9. In case it should be found absolutely necessary to deviate from the above directions, always *do the next best thing possible*, making note of such deviation on the blank provided.
10. Come to room 300 T. C. on the day after the experiment is finished for the purpose of taking the test.

All necessary materials for the test will be provided.

NOTE. Keep a daily record as called for on the blank provided.

The daily blank mentioned on the instruction sheet provided for a record of the hour when the study was done, the general conditions, i. e., physical, mental, etc., whether poor, good, or excellent, and whether or not there were any interruptions or other irregularities in the work.

Table I gives the exact date of each practice, the amount of time spent, and the number of repetitions of the bonds.

TABLE I

Date of Each Study-Period		*Equal* Schedule		*Reducing* Schedule	
		Time Spent	No. of Repet.	Time Spent	No. of Repet.
	1917				
Mon.	Oct. 29	20 min.	4		
Tues.	Oct. 30			40 min.	8
Wed.	Oct. 31			30 min.	6
Thurs.	Nov. 1	20 min.	4		
Fri.	Nov. 2			20 min.	4
Sat.	Nov. 3				
Sun.	Nov. 4	20 min.	4		
Mon.	Nov. 5			15 min.	3
Tues.	Nov. 6				
Wed.	Nov. 7	20 min.	4		
Thurs.	Nov. 8				
Fri.	Nov. 9			10 min.	2
Sat.	Nov. 10	20 min.	4		
Sun.	Nov. 11				
Mon.	Nov. 12				
Tues.	Nov. 13	20 min.	4	5 min.	1
	Totals	*120 min.*	*24*	*120 min.*	*24*

Thus we have, according to the plan of the experiment, an equal number of practice-periods spread over approximately (*Reducing* schedule one day shorter) the same total length of time. The total amount of time spent (120 min.), the average length of the study-periods (20 min.), and the total number of repetitions of the bonds (24) were the same for both schedules.

RESULTS OF THE EXPERIMENT

Two tests were given, the first on the day following the completion of the practice, and the second one week later. None of the subjects except the author, however, knew that a second test was to be given.

The order of the words in each list was rearranged for the purpose of the first test. List No. 1, which was studied according to the *Equal* schedule, was given first, and after a few minutes intermission list No. 2, which was studied according to the *Reducing* schedule, was given. In the second test, the words were presented in the original order in which they were studied, but the order of giving the two lists was reversed, i. e., list No. 2 was given first, and after a few minutes' intermission list No. 1 was given.

Three of the five subjects did better with the *Reducing* list in both tests; the other two consistently did better with the *Equal* list. The number of words attempted and the number recalled correctly by each of the subjects in both tests were as follows:

Subject	FIRST TEST				SECOND TEST			
	No. Attempted		No. Recalled		No. Attempted		No. Recalled	
	Equal	*Reduc.*	*Equal*	*Reduc.*	*Equal*	*Reduc.*	*Equal*	*Reduc.*
1—Alb.	133	148	127	145	130	135	117	125
2—Bar.	143	145	140	144	136	142	129	140
3—Cum.	129	145	114	130	135	142	124	133
4—Sen.	95	76	78	65	95	82	75	71
5—Coo.	111	90	103	77	117	103	93	87
Totals	*611*	*604*	*562*	*561*	*613*	*604*	*538*	*556*
Average			112.4	112.2			107.6	112.2
P. E.			14.8	27.9			16.0	21.8

The small amount of forgetting during the interval of one week between the first and the second tests, as shown by the above figures, may be partly accounted for by reference to three facts: (1) three of the subjects were studying beginning French at the time of the experiment; (2) one of the subjects (the author) had the advantage of going over both lists of words several times during the interim between the tests, in scoring the results of the first test; (3) the rearranging of the order of the words in the first test caused a lower score than otherwise might have been made, and the presenting of the words in their original order in the second test tended to give

a somewhat higher score than otherwise. Hence the amount of forgetting appears less than would have been the case had the conditions just described been reversed in the two tests, or even had they been made equal in both tests.

The influence of these factors does not, of course, in any way invalidate the comparison of the two schedules of distribution of practice, as both lists of words were influenced alike. The only effect would be to reduce the amount of forgetting shown during the interim between the two tests.

Combining the results of the two tests we have, for the five subjects, an average of 110 words recalled correctly for the *Equal* list and an average of 111.7 words recalled correctly for the *Reducing* list. Thus there is an average difference of 1.7 words in favor of the *Reducing* list. Owing to the large variability in the differences between the results of the two lists for the different subjects and the small number of subjects, the unreliability of this difference of 1.7 is very high. The P.E. of the *t.—obt.* Diff. is 3.56. This means that the chances are about even that the true difference with a large number of subjects will lie between 1.86, or about two per cent, in favor of the *Equal* schedule, and 5.26, or about six per cent, in favor of the *Reducing* schedule.

DISCUSSION OF THE TWO SORTS OF DISTRIBUTION

In general, the differences between these two sorts of distribution are as follows: (1) In respect to the length of the practice-period, the *Reducing* schedule has a larger number of repetitions occurring in the early part of the experiment, while with the *Equal* schedule the number of repetitions remains uniform for each practice-period throughout the experiment. (2) The length of the time-interval between periods gradually increases in the case of the *Reducing* schedule, while with the *Equal* schedule it remains constant.

The actual differences between the two schedules in our experiment, together with certain suggestions as to the possible influence of same upon the results, appear as follows: (1) The total length of time covered by the experiment was substantially the same (*Reducing* schedule one day shorter) for both schedules. (2) The number of practice-periods (six) was the same in both cases. (3) The number of repetitions of the bonds (twenty-four) was the same. (4) The length of the practice-periods was uniform (twenty minutes)

throughout for the *Equal* schedule, but for the *Reducing* schedule the length varied from forty minutes at the beginning of the experiment to five minutes at the close. (5) The time-interval between periods was uniform (three days) for the *Equal* schedule, while for the *Reducing* schedule it varied from one day at the beginning to four days at the close. In all other respects the conditions were substantially the same for both schedules.

Referring to the length of the practice-period it might be argued by some that a forty-minute period is too long for grade pupils, especially for the lower grades, as fatigue may set in, or the pupils become bored by so long a period of intensive work. So, also, it might be argued that a five-minute period is too short to allow for a proper 'warming up'. If these suppositions be true, then our *Reducing* group suffered a disadvantage.

On the other hand, the knowledge of a shorter practice-period at each succeeding time might, conceivably, serve as a stimulant. Moreover, the gradually decreasing length of the practice-period, together with an increasing interval between may be said to approximate more nearly the curve of forgetting; hence the *Reducing* schedule may, after all, be a more favorable arrangement.

With regard to the time-interval between periods, it would seem fair to conclude that neither schedule had any very great advantage, as no interval was shorter than twenty-four hours and none was longer than four days.

The optimum distribution of time has not, as yet, been determined in a sufficient number of cases to enable one to formulate any general rule that might be calculated to hold true for all situations. The whole matter is summed up by Thorndike in the following words:

> The experimental results obtained justify, in a rough way, the avoidance of very long practice-periods and of very short intervals. They seem to show, on the other hand, that much longer practice-periods than are customary in the common schools are probably entirely allowable, and that much shorter intervals are allowable than those customary between the first learning and successive 'reviews' in schools.
>
> What period-length shall be considered 'very long' depends on the amount of variety and satisfyingness the function shows. Two hours is, thus, a very long period for adding or learning 32-syllable nonsense series, but perhaps not for playing golf or chess.

What interval between periods shall be considered 'very short' depends on the length of the periods themselves, and also on the character of the function. For adding practised in twenty-minute periods, an interval of five minutes would be very short, and probably also one of five hours. The knowledge that would enable one to define the statement made in the text is lacking.

In a more recent work Hollingworth and Poffenberger confirm the above summary with the following statement:

The conclusion which has been drawn from experiments of this type is that too great concentration or distribution of time is not economical. The learning periods should be short enough to avoid the onset of fatigue, and long enough not to cause the loss of too much time in getting warmed up to the task at the beginning of the learning period.

According to Jost's law, stated in the Introduction, one would expect our *Reducing* schedule to show better results than the *Equal*, because of the piling up of repetitions in the earlier part of the experiment, which in turn would mean a larger number of bonds that were older when the same were exercised again later on in the experiment. Just how to equate this fact against the further fact that these older bonds would necessarily receive a fewer number of repetitions as compared with bonds of equal age in the *Equal* schedule, however, is a problem yet unsolved. It should, at least, be remembered that Jost's main argument was based upon the *re*-learning of associations which had been formed up to a given strength—that of producing one correct recall—and subsequently dropping below the limen through disuse, while most of the experimental work bearing upon the question of length of practice-period and time-interval between has been done by the exercising of subliminal bonds.

The results of our experiment showed a small difference in favor of the *Reducing* schedule. The large variability amongst individuals in the differences between the two schedules, as shown by the results obtained, together with the small number of subjects, gives the very high unreliability index of 3.56. This means that the chances are about four to one that the true difference with a large number of subjects will lie between 5.42 in favor of the *Equal* schedule and 8.82 in favor of the *Reducing*. The chances are about twenty-four to one that the true difference will lie between 8.98 in favor of the *Equal* schedule, and 12.38 in favor of the *Reducing*, or about ninety-nine to one that the true difference will lie between

12.54 in favor of the *Equal* schedule and 15.94 in favor of the *Reducing* schedule.

In the succeeding chapters will be found a report of an attempt to further answer this same question through a series of experiments with public school children working under ordinary everyday conditions. The same problem was also studied with a group of 157 normal school students acting as subjects. On account of certain difficulties arising from the attempt to use entirely new material in the experiment with school children, it was necessary to adapt material from that which is regularly used in the schools. This was done by making use of material taken from geography, history, addition, and division. A part of this same material was also used in the experiment with normal school students.

SECTION II

THE LYNDHURST EXPERIMENTS

I. DESCRIPTION

In order to avoid certain repetitions the experiments in learning geographical and historical facts and in practising addition and division will be described, not by topics, but by groups of individuals concerned.

CHARACTER OF THE SCHOOL POPULATION

Nationality. The Lyndhurst public schools at the time of our experiment (1914–15) had an enrollment of about 1,500 pupils in the grades, of which number approximately fifty per cent were foreign-born, being chiefly Italians and Poles. Taken altogether, we should say the population is somewhat below that of an average city of this size, in respect to the use of English.

Economic conditions. Because of the nature of the occupations followed by the citizens (railroad shops, New York business positions, etc.) there are few families that are either very poor or very well-to-do. All in all, the community would probably rank below, say, an average rural town of the same size in respect to general economic conditions.

Educational conditions. From the standpoint of equipment, the school system is fairly well provided for. The work done in the grades is accredited by the neighboring high schools. The teaching staff, composed of forty-two women, was well recommended and in charge of a competent supervising principal. As to the relative standing of the pupils in such functions as were tested, the reader is referred to the summary of all our experiments found at the close of Section IV.

In the Rutherford schools, from which we drew the seventh grade subjects for our experiment, there are few foreigners and more well-to-do homes. Here also we found a competent superintendent with an excellent corps of teachers.

SUBJECTS USED IN THE EXPERIMENT

The subjects consisted of 114 pupils from the seventh grade, 130 from the sixth grade, 127 from the fifth grade, 178 from the fourth

grade, and 150 from the third grade, making a total of 699 whose records were complete enough to count. The records of those who happened to be absent on either of the test days, together with those who were transferred in or out while the experiment was going on, were eliminated because of incompleteness.

CONTENT-MATERIAL USED

Geography. The material used for practice in geography was devised by the author. It consisted of condensed facts and principles printed on sheets six by ten inches in dimension. There were two sheets of a kind, one being used for study and the other for the test, the only difference being that on the test sheets certain important words were arbitrarily omitted.

The following are samples of the material:

PRINCIPLES OF GEOGRAPHY

(STUDY SHEET)

1. Geography is the (1) relation of the earth's surface to the (2) plants and (3) animals living upon it.
2. The earth's (4) crust is composed mostly of (5) rocks and detritus.
3. The earth is surrounded by a (6) mixture of oxygen, (7) nitrogen, and other gases called (8) air.
4. The larger portion of the earth's (9) surface is covered with (10) water, which is composed of two parts of (11) hydrogen to one part of (12) oxygen.

PRINCIPLES OF GEOGRAPHY

(TEST SHEET)

1. Geography is the (1) of the earth's surface to the (2) and (3) living upon it.
2. The earth's (4) is composed mostly of (5) and detritus.
3. The earth is surrounded by a (6) of oxygen, (7) and other gases called (8) .
4. The larger portion of the earth's (9) is covered with (10) , which is composed of two parts of (11) to one part of (12)

GEOGRAPHY OF SOUTH AMERICA

(STUDY SHEET)

South America as a continent ranks (1) fourth in size, is (2) less important in commerce than Europe, is shaped most like (3) North America, is (4) moist and hot in climate, except on the (5) western coast.

South America has (6) few good harbors, the best ones being in the country of (7) Chile, the chief mountains are the (8) Andes, and the great eastern expanse is called the (9) Brazilian highlands. Between this region and the (10) Guiana highlands is an extensive lowland drained by several large rivers,

GEOGRAPHY OF SOUTH AMERICA

(TEST SHEET)

South America as a continent ranks (1) in size, is (2) important in commerce than Europe, is shaped most like (3) , is (4) and hot in climate, except on the (5) coast.

South America has (6) good harbors, the best ones being in the country of (7) , the chief mountains are the (8) , and the great eastern expanse is called the (9) highlands. Between this region and the (10) highlands is an extensive lowland drained by several large rivers,

GEOGRAPHY OF EUROPE

(STUDY SHEET)

Europe is the smallest continent in the world, except (1) Australia, has a very (2) irregular coast line, with (3) many good harbors, produces crops very like (4) North America, has a well-developed system of (5) commerce both by land and by (6) water, the people belong mostly to the (7) white race, who engage chiefly in (8) agriculture in the plains, (9) fishing along the coast, (10) hunting in the tundra area, with extensive manufacturing in

GEOGRAPHY OF EUROPE

(TEST SHEET)

Europe is the smallest continent in the world, except (1) , has a very (2) coast line, with (3) good harbors, produces crops very like (4) , has a well-developed system of (5) both by land and by (6) , the people belong mostly to the (7) race, who engage chiefly in (8) in the plains, (9) along the coast, (10) in the tundra area, with extensive manufacturing in

History. For practice in history, the material was arranged after the same manner as that described for geography. The subject-matter, however, was taken from the summaries found at the end of the chapters in Montgomery's *Beginner's History of America.* The author is responsible for the arrangement and adaptation of

the text to suit the purpose of the experiment. There were five sheets of this material printed, the following being sample pieces of sheet No. 1:

AMERICAN HISTORY I

(STUDY SHEET)

About the year (1) 1000, (2) Leif Ericson, a Northman, discovered America. He called it (3) Vinland. The (4) Northmen did not stay in America, and the discovery did them no real good.

Nearly (5) 500 years later, Christopher Columbus, an (6) Italian, set out from (7) Spain to find a short (8) direct way to the (9) Indies by water. He crossed the (10) Atlantic and discovered (11) America in (12) 1492. But he thought the land he had seen was part of (13) Asia. He called it the

AMERICAN HISTORY I

(TEST SHEET)

About the year (1) , (2) , a Northman, discovered America. He called it (3) . The (4) did not stay in America, and the discovery did them no real good.

Nearly (5) years later, Christopher Columbus, an (6) , set out from (7) to find a short (8) way to the (9) by water. He crossed the (10) and discovered (11) in (12) . But he thought the land he had seen was part of (13) . He called it the

Division. For practice in this subject, the short division examples devised by Thorndike and rearranged by Kirby were used. In order to prevent the memorizing of the answers, three different sheets containing equal tasks were used. Each sheet contained approximately ninety-six examples, of which the following are samples:

20 = 5s	31 = 7s and r.	22 = 6s and r.
56 = 9s and r.	83 = 9s and r.	53 = 6s and r.
30 = 7s and r.	21 = 7s	33 = 4s and r.
89 = 9s and r.	54 = 8s and r.	77 = 8s and r.
20 = 8s and r.	32 = 4s	22 = 9s and r.
56 = 6s and r.	80 = 9s and r.	52 = 7s and r.
31 = 4s and r.	22 = 3s and r.	33 = 7s and r.
86 = 9s and r.	53 = 9s and r.	75 = 9s and r.

Addition. For practice in addition, the standard single-column addition sheets of Thorndike were used. By the use of four different sheets, each containing tasks of equal difficulty, the possibility of

memorizing the answers was reduced to a minimum. The following is a sample third of a sheet:

2	3	3	9	4	9	3	2	9	8	7	6	7	5	6	9
5	5	7	2	2	3	7	5	4	7	9	2	5	9	2	4
8	7	3	7	3	6	8	6	4	4	6	9	2	5	7	7
8	2	8	8	2	6	5	8	7	9	4	6	7	6	5	8
7	6	2	2	9	5	3	3	6	4	9	5	5	8	2	8
7	8	6	4	5	8	2	8	5	8	7	6	8	2	9	2
2	7	9	5	8	4	8	8	9	4	5	3	6	9	8	9
9	9	3	7	7	8	3	7	4	7	9	5	4	7	4	2
6	4	6	4	5	3	9	3	4	9	8	9	8	7	2	7
9	9	8	9	5	2	8	8	8	7	6	7	3	3	7	6
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

PLAN OF THE EXPERIMENT

Our general plan was to conduct the experiment under ordinary school conditions, equalizing all the factors save that of distribution of practice. The general principle followed in the arrangement of the two schedules was that discussed in the previous section. This necessarily involved differences in the length of the practice-periods and in the intervals between the periods. In most cases there was also a difference in the number of practice-periods.

Table II shows the exact arrangement of the time-schedule for the four sixth grade classes which learned geography and history. Table III exhibits similar data for the five seventh grade classes which learned principles of geography. Table IV gives the data for the eleven third and fourth grade classes which practised addition and the four fifth grade classes which practised short division.

TABLE II

THE NUMBER OF MINUTES DEVOTED TO EACH PRACTICE-PERIOD IN THE CASE OF CLASSES 'P' AND 'Q' WHICH LEARNED GEOGRAPHICAL FACTS, AND CLASSES 'R' AND 'S', WHICH LEARNED HISTORICAL FACTS

These were sixth grade classes from the Lyndhurst schools.

1915 Feb.	p 6	q 6	r 6	s 6
9	20	20	20	20
10	..	..	..	..
11	..	15	..	15
12	20	..	20	..
13	..	..	..	..
14	..	..	..	..
15	..	12½	..	12½
16	20	12½	20	12½
17	..	10	..	10
18	20	10	20	10
19	..	7½	..	7½
20	..	..	..	..
21	..	..	..	..
22	20	7½	20	7½
23	..	5	..	5
24	20	20	20	20

TABLE III

THE NUMBER OF MINUTES DEVOTED TO EACH PRACTICE-PERIOD IN THE CASE OF CLASSES 'T', 'U', 'V', 'W', AND 'X', WHICH LEARNED GEOGRAPHICAL FACTS

These were seventh grade classes from the Rutherford schools.

1915 Mch.	t 7	u 7	v 7	w 7	x 7
5	15	15	15	15	15
6	..	..	..	..	..
7	..	..	..	..	..
8	15	15	15	15	15
9	..	..	..	..	..
10	15	15	10	10	10
11	..	..	..	..	..
12	15	15	10	10	10
13	..	..	..	..	..
14	..	..	..	..	..
15	..	..	..	..	..
16	..	..	..	..	..
17	15	15	15	15	15
18	..	..	..	..	..
19	..	..	10	10	10
20	..	..	..	..	..
21	..	..	..	..	..
22	15	15	10	10	10
23	..	..	..	..	..
24	..	..	7½	7½	7½
25	..	..	..	..	..
26	15	15	7½	7½	7½
27	..	..	..	..	..
28	..	..	..	..	..
29	..	..	5	5	5
30	..	..	..	..	..
31	15	15	15	15	15

TABLE IV

THE NUMBER OF MINUTES DEVOTED TO EACH PRACTICE-PERIOD, IN THE CASE OF CLASSES 'A' TO 'K', INCLUSIVE, WHICH PRACTISED SINGLE-COLUMN ADDITION AND CLASSES 'L', 'M', 'N,' AND 'O', WHICH PRACTISED SHORT DIVISION

These were third, fourth, and fifth grade classes from the Lyndhurst schools.

1914 Nov.	a 3	b 3	c 4	d 4	e 4	f 4	g 4	h 3	i 3	j 4	k 3	l 5	m 5	n 5	o 5
2	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4	..	5	15	15	10	10	5	5	..	..	..	..	..	..	..
5	10	..	..	..	..	..	5	5	..	15	..	..	..	..	..
6	..	5	10	10	10	10	5	5	..	15	15	15	15	10	10
7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
9	..	5	..	..	10	..	5	5	..	15	10	10	10	10	10
10	10	5	10	10	..	10	5	5	..	15	..	..	..	..	..
11	..	5	..	..	10	..	5	5	..	..	..	..	..	10	10
12	10	5	7½	7½	..	10	10	10	..	10	10	10	10	10	10
13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16	..	5	..	..	10	10	5	5	..	..	..	..	..	10	10
17	..	..	5	5	..	..	5	5	..	..	7½	7½	7½	..	..
18	10	5	..	..	10	10	5	5	..	..	..	..	..	10	10
19	..	5	..	..	..	..	5	5	..	..	..	..	..	..	..
20	..	..	2½	2½	10	..	5	5	..	..	5	5	5	10	10
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
23	10	5	..	..	..	10	5	5	..	..	2½	2½	2½	..	..
24	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
25	7½	7½	7½	7½	..	..	..	..	15	..	..	7½	7½	..	..
26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
28	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..	..	15	..	..	..	..	..	..
D. 1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	5	5	5	5	..	..	..	..	15	..	..	5	5	..	..
3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE IV (*Continued*)

1914 Dec.	a 3	b 3	c 4	d 4	e 4	f 4	g 4	h 3	i 3	j 4	k 3	l 5	m 5	n 5	o 5
5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
9	5	5	5	5	..	..	..	..	15	..	..	5	5	..	..
10	..	..	..	..	..	..	..	..	15	..	..	..	..	..	..
11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16	2½	2½	2½	2½	..	..	..	..	10	..	..	2½	2½	..	..
17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
18	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15

ADMINISTRATION OF THE EXPERIMENT

The author was accorded the most favorable advantages for carrying out the experiment. Full permission was granted to interrupt classes at any hour, the class being turned over by the teacher immediately upon our entering the room. Whenever possible, the practice was done at the regular recitation period for the subject that was to be used. Thus, in the experiment with geography and history, the practice was done at the regular recitation period for these subjects.

Method of conducting the experiment. All the initial and final tests, as well as all the intervening practice-periods, with but few exceptions, were conducted by the author. In all cases where assistance was rendered, the teachers were thoroughly familiarized with the work beforehand; hence, there is probably no appreciable difference in the results due to the small amount of teacher-assistance that was used.

The method of procedure used in all the rooms was as follows: As soon as we had entered the room the teacher had all the work cleared from the pupils' desks and immediately turned the class over to us, she herself either leaving the room or, if remaining, assuming the attitude of one of the group.

The first step was to explain and illustrate the nature of the work to be done. It was found that this could best be done by placing

before the pupils a sample of the work and allowing them to try it for themselves. In the case of those classes which learned geography and history the study sheets were first passed out, the only instructions necessary being simply to say, "We are going to study this text a little while, and the way we are going to study it is simply to read it over in concert, all following the leader. I will be the leader. All ready, Read!"

After having read over a few of the sentences, attention was called to the words immediately following the numbers, as being the most important ones to remember. Having put in the required amount of time in study, these sheets were collected and the test sheets, together with blank sheets on which to write the words, were passed out. The pupils were instructed to read over the sentences on the test sheets, endeavoring to recall as many of the omitted words as possible, and to write them in order on the blank sheets of paper provided. They were admonished not to spend too much time in trying to think of any particular word. In case a word could not be recalled within, say, five or ten seconds, they were simply to draw a line instead on the scoring sheet and pass on to the next, the object being to get down as many words as possible within the time.

By preliminary testing with adults, it was found that approximately seven minutes were required to read over two of the study sheets. It was also judged that two sheets, which contained on an average about seventy test words each, would be sufficient to measure the ability of the best pupils, in a test not to exceed twenty minutes in length. Two sheets, therefore, were taken as the unit of material to be learned. By this arrangement, the bonds to be tested were exercised on an average from fourteen to seventeen times during the experiment.

In initiating the practice with addition and division, a sample piece of a sheet was placed before each pupil, and, after a brief illustration on the blackboard, the following general directions were given: "When the signal is given you are to begin and add (or divide, as the case might be) as many of the examples as you can until you are told to stop. You are to have about three minutes. The signal to begin will be 'Ready, Go!' The signal to stop will be 'Pencils down!' You must work as hard as you can, but don't make any mistakes."

The trial was made, the trial papers were taken up, new sheets were distributed with the figures down, whereupon the experimenter asked, "When the signal is given, what are you to do?"

To which the class replied in concert, "Turn over the papers, work as hard as we can, and don't make any mistakes." "Very well," said the experimenter, "you are to have *five* minutes this time; all ready, Go!" and the real experiment was begun.

In the case of single-column addition, such as was used, there are thirty-seven possible bonds that may be exercised. Since there are ten digits to a column, each bond occurs by chance once in every four columns. Thus the bonds tested were exercised on an average from ten to fifty or more times each during the course of the experiment, depending upon the total number of columns added.

Incentives used. The incentives used in general were those ordinarily used in school work, viz., class pride, individual pride, small material rewards, and the idea of competing with one's own past record. This last-named incentive, however, was made more emphatic than it is ordinarily made by the teacher.

The appeal to class pride was made by announcing to each class that a comparison was to be made of the records of the different classes. Personal pride was called forth by reporting from day to day the names of those pupils who showed improvement. The material rewards given consisted of a silver half-dollar to the pupil who showed the largest per cent of individual improvement, and a silver quarter-dollar to the one who showed the next largest per cent of individual improvement, in both the third and fourth grades. The idea of competing with one's own record was illustrated from time to time, and the indications were that a majority of all the pupils understood it and were stimulated by it. Indeed, many were very much influenced by this form of incentive, as was evidenced by the fact that they kept track of their own improvement from day to day. It is not claimed that our pupils were stimulated to any unusual degree, for the intention was to get only such results as might reasonably be expected of any similar set of pupils working under like conditions. Our pupils worked, we should say, as faithfully as the average pupils work in any ordinary school system under ordinary everyday conditions.

SCORING AND TABULATING THE RESULTS

Geography and history. The score was the number of words remembered and correctly written. The per cent of words attempted that was found correct was taken as the index of accuracy. Inasmuch

as most of the time was taken up with the study of the text, no attempt was made to keep a daily record of the scores.

Since a pupil would sometimes apparently understand the meaning of a sentence, but could not recall the exact word that had been omitted from the test sheet, it was necessary to standardize the various substitutions that were made. This was accomplished by assigning each substituted word to one of three classes, designated as Full credit (F. C.), Half credit (H. C.), or Rejected (R.). These lists constituted a guide for the uniform scoring of all the papers in geography and history.

Below are given some of the more interesting substitutions made by various pupils, classified according to the probable explanation of each.

1. *Substitutions apparently due to the lack of knowing how to spell the word correctly:* "lamor," "lamma" for "llama," F. C.; "brazla" for "Brazil," H. C.; "guaquil" for "Guayaquil," F. C.; "Dublon" for "Dublin," F. C.; "Carcas" for "Caracas," F. C.; "Venemeeda" for "Venezuela," R.

2. *Substitutions evidently due to a confusion of words:* "Tampico" for "tapioca," R.; "area" for "rhea," R.; "revelations" for "revolutions," R.; "channels" for "canals," H. C.

3. *Substitutions of words having similar meanings:* "some" for "few," F. C.; "lowlands" for "plains," F. C.; "wrote" for "published," H. C.; "ways" for "habits," H. C.; "liberty" for "freedom," F. C.

4. *Substitutions of words with similar meanings but in which case the distinction is rather more important than in* (3) *above:* "everlasting" for "constant," F. C.; "red" for "copper," F. C., when referring to the color of the Indians, but "brown" for "copper," R., because this would not distinguish the Indians from certain other races.

5. *Substitutions representing different degrees of comprehensiveness of thought:* "U. S." for "America," F. C.; for pupils in the fifth and sixth grades, but only H. C. for seventh and eighth grades. "Palos" for "Spain," F. C., when designating the place from which Columbus sailed; "battles" for "wars," F. C.; "fur" for "hair," H. C.; "meat" for "mutton," H. C.; "steel" for "magnet," R.; "housework" for "work," R., the reference being to the Indian squaw, who does most of the "work."

Addition and division. In the case of these two subjects all the time allotted to each practice-period was used in solving as many of the examples as possible, hence it was possible to keep complete daily scores. The score was the number of examples solved correctly. The accuracy was recorded as:

$$\frac{\text{number of problems done correctly}}{\text{number of problems attempted}}.$$

Samples of the daily records of the two classes are given below. The numbers down the left-hand margin are for the identification of the pupils. The letters 'A' and 'E' at the top refer, respectively, to the number of examples attempted and to the number of errors made. The figures above the letters represent the number of minutes devoted to each practice-period.

SAMPLE NO. 1, FROM THE DAILY RECORD OF CLASS "F," WHICH FOLLOWED THE *Equal* SCHEDULE

Boys	15		10		10		10		10		10		10		10		15		15	
	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E
1	18	4	12	5	18	13	18	1	27	3	..	..	13	1	23	2	28	8	32	7
2	..	..	8	2	8	3	8	1	8	1	9	1	12	4	12	3	..	..	..	..
3	17	8	15	10	14	8	12	6	16	4	16	8	11	8	13	10	16	12	31	14
4	20	3	18	4	41	36	31	11	19	0	11	0	22	18	47	46	48	45	48	25
5	13	2	20	5	19	3	18	0	11	0	15	1	15	3	15	4	18	4	30	4
6	28	14	27	21	32	32	19	7	30	20	27	11	37	21	28	20	44	32	44	30
7	31	16	39	39	24	22	32	9	26	23	16	12	..	..	25	7	43	34	48	30
8	15	13	16	6	10	9	23	12	14	1	12	4	13	3	9	2	24	23	..	..
9	16	3	20	8	16	8	..	..	23	6	..	..	14	6	16	10	21	11	..	..
10	20	4	27	5	23	6	..	..	..	..	25	7	31	12	24	7	39	12	48	18

SAMPLE NO. 2, FROM THE DAILY RECORD OF CLASS "C," WHICH FOLLOWED THE *Reducing* SCHEDULE

Girls	15		15		10		10		7½		5		2½		15		7½		5		5		2½		15	
	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E
1	31	27	19	12	13	12	13	6	5	3	3	0	2	2	14	3	11	5	7	3	11	8	3	1	20	16
2	35	6	38	3	26	14	18	2	14	1	9	0	7	1	21	1	17	0	16	2	15	0	5	0	40	8
3	9	7	13	7	10	6	9	2	8	4	7	2	3	1	17	6	8	6	7	5	8	6	4	3	19	12
4	27	5	28	5	21	6	13	3	16	3	14	3	8	1	29	8	19	2	12	3	12	2	6	0	..	..
5	14	4	19	5	..	..	10	2	10	2	9	1	4	2	20	5	13	4	7	1	9	1	4	0	24	5
7	27	7	24	8	18	15	20	6	15	3	13	2	6	1	33	5	15	7	9	4	11	2	6	0	30	15
8	18	6	31	15	15	7	12	4	13	3	16	6	3	1	16	7	14	3	9	1	9	2	4	1	..	..
11	15	6	19	6	17	6	..	..	4	0	4	1	2	1	8	1	13	4	..	..	..	..	..	..	..	..
12	12	9	15	8	6	4	6	3	7	3	6	2	5	1	15	5	10	3	7	3	8	3	5	1	16	12
13	9	4	15	5	13	5	15	2	11	0	7	1	3	0	19	1	10	1	6	2	6	4	3	0	20	7

In scoring the daily practice done in addition and division, the assistance of three grammar grade boys was employed. They were paid nominal wages for the work, which was done on Saturdays and other school holidays. The work was done under the supervision of the author, who himself did the scoring of the initial and the final tests, also all the tabulating of the results. The work of scoring the papers was reduced to a mere matter of comparison, by the use of 'key sheets'. The 'key sheets' contained the correct answers so arranged that, when superimposed upon the test sheets, the correct answers appeared alongside of the answers put down by the pupils. Thus it was an easy matter to check the wrong answers. The accuracy of the work done by the helpers was checked from time to time by the author.

All the original daily records for addition and division in both the Lyndhurst and the Ohio experiments were preserved. These original records furnish a mass of data that is valuable for the study of various other problems, such as individual differences, individual learning curves, sex differences, etc. In view of the fact that most of the time spent in the geography and history experiments was taken up in study, the daily scores for these subjects were of little significance, and were not preserved.

2. RESULTS OF THE LYNDHURST EXPERIMENTS

This section will exhibit the results of the Lyndhurst experiments in the form of tables of frequencies. The frequencies given are in terms of the initial scores, the per cent of problems correct in the initial test, and the change that took place in these two respects, as a result of the 100 minutes of practice that was measured.

TABLES OF FREQUENCIES

Table V gives the frequencies for the initial scores made by the *Equal* and the *Reducing* groups. The comparison is made grade by grade, except in the case of the third and fourth grades, the data for which grades are combined. Table VI gives the frequencies for the per cent of problems solved correctly in the initial test. Table VII gives the frequencies for the amount of change that took place, in the number of problems correctly solved, during the time of the experiment. Table VIII gives the frequencies for the change that took place in respect to the per cent of problems solved correctly.

The total amount of time consumed in each of the geography and history experiments was 120 minutes. The initial score was counted as the average, or mid-point, of the first twenty minutes of practice, and the final score was counted as the average, or mid-point, of the last twenty minutes of practice. Hence, the amount of practice that was measured was that which lies between these two mid-points, or 100 minutes.

The total amount of time consumed in each of the addition and division experiments was 115 minutes. In this case, however, the initial and final scores were counted at the average, or mid-point, of the first and last *fifteen minutes* of practice, respectively, hence the amount of practice that was measured was again just 100 minutes.

The results of the geography and history experiments were influenced by two facts. First, a few minutes of study were allowed before the initial test was given, in order that the pupils might become acquainted with the nature of the material. Thus there is included in the initial score a slight effect due to immediate memory. This fact, as may readily be seen, has the tendency to make the initial score higher than it otherwise would have been, and to make the amount of gain shown during the time of the experiment less than it otherwise would have been. Second, there was no study immediately preceding the final test, hence the amount of gain reported is still further decreased below what it would have been, with an equality of these conditions.[1]

[1] This does not, of course, affect the comparison of the two sorts of distribution of practice, but only the amount of gain shown during the experiment as a result of the 100 minutes of practice with the functions concerned.

TABLE V

INITIAL ABILITY IN THE LYNDHURST EXPERIMENTS: FREQUENCIES FOR INITIAL SCORES

The figures at the top represent the number of problems solved correctly in the initial test, which was 20 minutes in the case of geography and history, and 15 minutes in the case of addition and division.

The table reads as follows: Of the 56 seventh grade pupils who learned geographical facts according to the *Equal* schedule, there were none who made scores of 0, plus 1, 2, 3 .... 9; 2 made scores of 10, 11, 12, 13, or 14; none made scores of 15, 16, 17, 18, or 19; 10 made scores of 20, 21, 22, or 23, 24, etc.

Time Dist.	No. of Pupils	Grade	Material	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39	40 44
Equal	56	7	Geog.	..	..	2	..	10	13	20	7	3
Reduc.	58	7	Geog.	..	..	1	1	10	11	13	11	6
Equal	30	6	Hist.	..	..	2	2	5	9	6	2	9
Reduc.	31	6	Hist.	..	..	..	2	1	3	4	6	6
Equal	34	6	Geog.	..	..	..	..	..	1	3	4	9
Reduc.	35	6	Geog.	..	..	1	..	2	8	3	7	4
Equal	56	5	Div.	..	1	..	1	3	2	5	3	2
Reduc.	71	5	Div.	3	..	..	3	1	4	3	1	4
Equal	175	3, 4	Add.	25	34	53	32	20	6	3	1	1
Reduc.	153	3, 4	Add.	34	39	34	21	15	4	5	1	..

(Above Table continued)

Time Dist.	45 49	50 54	55 59	60 64	65 69	70 74	75 79	80 84	85 89	90 94	95 99	100 109	110 119	120 129	130 139	140 149	150 159
Equal	1	..	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...
Reduc.	3	2	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...
Equal	1	1	1	..	..	..	..	..	..	..	..	..	..	..	...	...	...
Reduc.	2	4	1	2	..	..	..	..	..	..	..	..	..	..	...	...	...
Equal	5	6	4	2	..	..	..	..	..	..	..	..	..	..	...	...	...
Reduc.	3	5	1	1	..	..	..	..	..	..	..	..	..	..	...	...	...
Equal	..	3	6	1	4	5	2	4	3	1	1	2	3	3	...	...	1
Reduc.	3	2	5	7	4	2	3	5	..	4	1	5	2	3	2	3	1
Equal	..	..	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...
Reduc.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...

TABLE VI

INITIAL ABILITY IN THE LYNDHURST EXPERIMENTS: FREQUENCIES FOR PER CENT OF ACCURACY

The figures at the top represent the per cent of problems solved correctly of all that were attempted in the initial test.

The table reads as follows: Of the 56 seventh grade pupils who learned geographical facts, according to the *Equal* schedule, there were none who showed as low a per cent of accuracy in the initial test as 0, 1, 2, 3 ..... 49; one fell as low as 50, 51, 52, 53, or 54 per cent; 1 fell as low as 55, 56, 57, 58, or 59; 3 showed 60, 61, 62, 63, or 64 per cent, etc.

Time Dist.	No. of Pupils	Grade	Material	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39	40 44
Equal	56	7	Geog.	..	..	..	..	...	...	...	...	...
Reduc.	58	7	Geog.	..	..	..	..	...	...	...	...	...
Equal	30	6	Hist.	..	..	..	..	...	...	...	...	1
Reduc.	31	6	Hist.	..	..	..	..	...	...	...	...	1
Equal	34	6	Geog.	..	..	..	..	...	...	...	...	...
Reduc.	35	6	Geog.	..	..	..	..	...	...	...	...	...
Equal	56	5	Div.	..	..	1	..	...	...	...	...	...
Reduc.	71	5	Div.	2	1	..	..	...	...	1	...	1
Equal	175	3, 4	Add.	9	3	3	1	4	4	7	7	4
Reduc.	153	3, 4	Add.	9	4	3	2	4	11	2	9	14

(*Above Table continued*)

Time Dist.	45 49	50 54	55 59	60 64	65 69	70 74	75 79	80 84	85 89	90 94	95 99	100
Equal	..	1	1	3	4	10	11	11	11	4	...	...
Reduc.	..	2	6	1	11	3	12	14	6	3	...	...
Equal	1	..	2	4	5	3	2	6	4	1	1	...
Reduc.	..	..	..	3	3	4	5	7	3	5	...	...
Equal	..	1	1	2	4	2	10	8	6	...	...	...
Reduc.	..	2	1	4	4	5	9	9	1	...	...	...
Equal	..	..	1	..	1	...	4	6	12	15	13	3
Reduc.	1	..	1	..	1	4	5	4	6	14	25	5
Equal	6	11	13	22	14	9	11	13	18	7	6	3
Reduc.	2	14	8	11	10	14	10	9	10	4	1	2

TABLE VII

AMOUNT OF IMPROVEMENT IN THE LYNDHURST EXPERIMENTS: TOTAL SCORE

The figures at the top represent the amount of improvement, plus or minus, that took place during the time of the experiment in the number of problems correctly solved.

The table reads as follows: Of the 56 seventh grade pupils who learned geographical facts according to the *Equal* schedule, there were none who made an improvement of minus 25, 24, 23 .....1; none showed an improvement of 0, plus 1, 2, 3 .....9; 1 showed an improvement of plus 10, 11, 12, 13, or 14; 5 showed plus 15, 16, 17, 18, or 19, etc.

Time Dist.	No. of Pupils	Grade	Material	−25 21	−20 16	−15 11	−10 6	−5 1	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39
Equal	56	7	Geog.	..	..	..	..	..	..	..	1	5	6	7	8	2
Reduc.	58	7	Geog.	..	..	..	..	..	1	1	..	..	1	5	2	8
Equal	30	6	Hist.	..	1	1	3	3	5	6	3	4	..	..	..	2
Reduc.	31	6	Hist.	..	..	..	..	..	..	1	1	1	1	..	6	4
Equal	34	6	Geog.	..	..	..	..	..	4	2	4	5	7	3	4	4
Reduc.	35	6	Geog.	..	..	..	3	1	2	2	3	3	6	..	4	5
Equal	56	5	Div.	..	..	..	1	..	2	..	2	3	3	1	2	1
Reduc.	71	5	Div.	..	..	..	1	..	..	1	..	..	2	3	1	4
Equal	175	3, 4	Add.	..	..	1	9	34	44	33	24	15	11	2	..	1
Reduc.	153	3, 4	Add.	1	1	..	7	17	47	30	25	15	6	3	1	..

(Above Table continued)

Time Dist.	40 44	45 49	50 54	55 59	60 64	65 69	70 74	75 79	80 84	85 89	90 94	100 109	110 119	120 129	130 139	140 149	150 159
Equal	5	8	2	3	2	1	1	2	1	2	..	..	..	..	...	...	...
Reduc.	6	7	5	6	6	2	2	2	2	2	..	..	..	..	...	...	...
Equal	..	2	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...
Reduc.	6	4	2	3	1	1	..	..	..	..	..	..	..	..	...	...	...
Equal	..	1	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...
Reduc.	1	..	2	3	..	..	..	..	..	..	..	..	..	..	...	...	...
Equal	1	3	2	7	2	1	6	5	1	2	2	3	1	1	2	1	1
Reduc.	7	3	3	4	6	4	2	6	3	1	6	4	1	3	3	2	...
Equal	1	..	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...
Reduc.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...

TABLE VIII

AMOUNT OF IMPROVEMENT IN THE LYNDHURST EXPERIMENTS: PER CENT CORRECT

The figures at the top represent the amount of improvement, plus or minus, in the per cent of problems correctly solved, of all that were attempted, that took place during the time of the experiment.

The table reads as follows: Of the 56 seventh grade pupils who learned geographical facts according to the *Equal* schedule, there were none who showed an improvement of minus 85, 84, 83 ..... 21, in the per cent of problems correctly solved; 3 showed an improvement of minus 20, 19, 18 17, or 16; 1 showed minus 15, 14, 13, 12, or 11; etc.

Time Dist.	No. of Pupils	Grade	Material	−85 81	−80 76	−75 71	−70 66	−65 61	−60 56	−55 51	−50 46	−45 41	−40 36	−35 31	−30 26	−25 21
Equal	56	7	Geog.	..	..	..	..	..	..	..	..	..	..	..	..	..
Reduc.	58	7	Geog.	..	..	..	..	..	..	..	..	..	..	..	..	..
Equal	30	6	Hist.	..	..	..	..	..	..	..	..	1	..	..	..	..
Reduc.	31	6	Hist.	..	..	..	..	..	..	..	..	..	..	..	..	..
Equal	34	6	Geog.	..	..	..	..	..	..	..	..	..	..	..	..	1
Reduc.	35	6	Geog.	..	..	..	..	..	..	..	..	..	..	..	1	1
Equal	56	5	Div.	..	..	..	..	..	..	..	..	..	1	..	..	..
Reduc.	71	5	Div.	..	..	..	..	..	..	..	..	..	1	..	..	1
Equal	175	3, 4	Add.	1	..	..	..	..	3	1	..	1	6	6	9	7
Reduc.	153	3, 4	Add.	..	..	..	1	1	..	1	2	1	5	1	2	6

(Above Table continued)

Time Dist.	−20 16	−15 11	−10 6	−5 1	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 74	75 79
Equal	3	1	10	11	14	6	4	5	1	1	..	..	..	..	..	..	..	..	..	..
Reduc.	1	1	3	5	9	9	13	5	9	3	..	..	..	..	..	..	..	..	..	..
Equal	1	1	4	6	4	7	2	1	2	1	..	..	..	..	..	..	..	..	..	..
Reduc.	..	..	1	8	7	9	4	2	..	..	..	..	..	..	..	..	..	..	..	..
Equal	2	2	2	4	14	6	3	..	..	..	..	..	..	..	..	..	..	..	..	..
Reduc.	1	2	2	5	7	5	9	2	..	..	..	..	..	..	..	..	..	..	..	..
Equal	..	..	3	5	18	12	11	2	1	1	..	1	..	..	..	..	..	..	1	..
Reduc.	..	..	1	9	32	9	4	3	3	2	1	1	..	..	..	1	3	..	..	..
Equal	15	12	19	8	19	14	8	12	10	7	3	5	2	1	4	1	..	..	..	1
Reduc.	4	3	10	13	17	17	18	11	8	7	8	4	3	2	4	..	..	1	3	..

COMPARISON OF THE TWO SORTS OF DISTRIBUTION

(*a*) *Geography and history.* Next in order, after the discussion of the learning of new bonds from zero strength contained in Chapter I, we are able to compare the results obtained from the application of the two different schemes of distribution to the learning of geographical and historical facts—bonds which had already been exercised to a considerable extent through the study of these subjects in the regular class work of the sixth and seventh grades.

For the purpose of comparison, the seventh grade classes, whose time schedules are shown in Table III, on page 16 above, are divided into the *Equal* group, including classes 't' and 'u', which had schedules with practice-periods of equal length, and the *Reducing* group, including classes 'v', 'w', and 'x', which had practice-periods decreasing in length and on the average much shorter than those of the *Equal* group. The experiment with these seventh grade classes extended over a period of twenty-six days, from the 5th to the 31st of March. The average length of the practice-periods for the *Equal* group was fifteen minutes, that for the *Reducing* group slightly less than eleven minutes.

Also, we may divide the sixth grade classes into two similar groups. The time schedules for these classes are given in Table II, on page 16 above. The *Equal* group included classes 'p' and 'r', which had schedules with practice-periods of twenty minutes in length. The *Reducing* group included classes 'q' and 's', which had schedules with practice-periods decreasing in length and averaging just twelve minutes. The experiment with these sixth grade classes extended over a period of fifteen days, from the 9th to the 24th of February.

In both cases the results show a greater improvement for the groups which followed the *Reducing* schedule, roughly speaking, one-seventh more. The facts appear in Table IX.

TABLE IX

COMPARISON OF RESULTS OBTAINED FROM THE TWO SORTS OF DISTRIBUTION IN THE LYNDHURST EXPERIMENTS

Time Dist.	Grade and Class	No. of Pupils	Material Practiced	Average Age	Average No. Correct in Init. Test	Average Gross Gain in No. Correct	Per cent in Init. Test Correct of Problems Attempted	Gain in Per cent Correct
Equal	7, t, u	56	Geog.	13.52	29.89	40.84	77.55	1.44
Reduc.	7, v,w, x	58	Geog.	12.81	30.67	48.86	74.88	8.91
Equal	6 p	34	Geog.	11.50	45.50	21.15	76.74	.47
Reduc.	6 q	35	Geog.	12.37	37.74	24.29	72.72	1.54
Equal	6 r	30	Hist.	12.10	31.10	8.47[1]	72.67	.87
Reduc.	6 s	31	Hist.	12.30	39.52	40.25	77.26	3.42

We have, then, to inquire whether other factors than the nature of the distribution of practice might have caused this difference.

Teacher. The factor of the teacher was rendered constant so far as possible, by the facts (1) that both the initial and final tests, and all the daily practice, with few exceptions, were conducted by the author, and (2) that these exceptions came by pure chance, and thus would be as likely to favor one group as the other.

Time of day. The factor of time of day was equalized for the two groups by experimenting with the classes in an order that was random, so far as the time of day was concerned.

Amount of previous practice. This factor could in no wise be determined, except in so far as being in the same grade in school might imply an equal amount of previous practice in any given function, as, for example, arithmetic, or geography. In comparing pupils of the same grade, taken at random as ours were, it would seem fair to suppose, for example, that thirty pupils (class c) in the fourth

[1] The very small gain shown by this class is probably due to special circumstances to be reported later.

grade in one building would have had as much practice, let us say in the function of addition, as had thirty-one pupils (class f) in the fourth grade in another building in the same school system, in which the distribution of pupils among the several buildings was based upon the place of residence of the pupils.

Age. Referring to Table IX, in which is given the average age for each group, it will be seen that there is a difference of less than half a year between the two groups in either of the three comparisons. On the whole, the two groups are substantially equal in point of age. For, if we combine the three *Equal* groups into one larger group, and the three *Reducing* groups into one larger group, we have an average age of 12.37 years for the *Equal* group and 12.49 years for the *Reducing* group. So small a difference as .12 of a year in the average age of two groups is practically negligible.

Mental attitude of the pupils. Over this factor we could exercise very little control, owing to the short length of time in which we had charge of the classes. This factor, however, appeared to be fairly well distributed between the two groups, except in the case of a certain sixth grade class which learned history. It so happened that this particular class had been predetermined to follow the *Equal* schedule. On nearly every occasion when we entered this room the teacher was at swords' points, so to speak, with some of the larger boys in the class. This was noticeably so on the day of the final test, as a result of which the score of this class was materially reduced from what it otherwise might have been. Due allowance will be made for this disturbance at the proper time.

Physical conditions. Such conditions as light, heat, ventilation, seating arrangement of the pupils, etc., were fairly uniform in all the buildings, since each building was in good repair and well kept. These advantages were shared equally by the two groups.

Physiological conditions. During the time of our experiment there were no gross disturbances, such as epidemics, and no minor disturbances of any kind affecting one group more than the other.

Interest and worry. The psychological factors of interest and worry, in so far as we were able to discern, were equally favorable to both groups.

Initial ability. The initial ability of the two groups differed somewhat, but upon the whole was substantially the same. The facts appear as follows:

AVERAGE INITIAL SCORES

Subject	Grade	*Equal* Group	*Reducing* Group
Geography	7	29.89 (No. P. 56)	30.67 (No. P. 58)
Geography	6	45.50 (No. P. 34)	37.74 (No. P. 35)
History	6	31.10 (No. P. 30)	39.52 (No. P. 31)

Since the correlation between initial score and gross gain, though probably positive, is low [1] the differences shown here would not seriously affect any substantial difference due to the distribution of practice.

Differences in initial ability, however, may be eliminated by the 'pairing off' method, i. e., leaving out the initially better from one group and the initially poorer from the other group, until the *Equal* and the *Reducing* groups consist of pupils of equal average initial ability. The following results, for the two groups in question, are obtained by this sort of treatment:

COMPARISON OF RESULTS OF THE *Equal* AND THE *Reducing* GROUPS, AFTER EQUALIZING INITIAL ABILITY BY THE METHOD OF 'PAIRING OFF' THE INITIAL SCORES OF THE TWO GROUPS

Group	Grade	Material	No. of Pupils	Initial Score	Gross Gain
Equal	7	Geog.	52 (56)	30.77 (29.89)	41.96 (40.84)
Reduc.	7	Geog.	53 (58)	30.76 (30.67)	47.11 (48.86)
Equal	6	Geog.	28 (34)	43.04 (45.50)	19.54 (21.15)
Reduc.	6	Geog.	25 (35)	42.88 (37.74)	29.24 (24.29)
Equal	6	Hist.	23 (30)	34.26 (31.10)	9.13 [2] (8.47)
Reduc.	6	Hist.	22 (31)	34.18 (39.52)	38.77 (40.25)

[1] See especially the results of Chapman ('15) and Thorndike ('16).

[2] Special disturbances characterized this group. See the paragraph on *Mental attitude of the pupils* on page 31.

If the results thus obtained are compared with those given in Table IX, it will be seen that the equalization of initial ability does not reduce the advantage shown in favor of the *Reducing* group, but rather increases it. Combining the results, we have, as a net result of equalizing the initial ability of the two groups, a gain of 9.25 per cent on the initial score, for the *Reducing* groups, whereas the *Equal* groups suffer a loss of 1.98 per cent on their initial score by this method of treatment. Leaving out the doubtful case in which special disturbances occurred, the gross gain made by the *Reducing* groups is approximately one and a quarter times that made by the *Equal* groups.

Recency of last practice before the final test. In the experiment with seventh grade pupils the *Reducing* group had a five-minute practice-period two days before the final test and a seven and one-half minute practice-period five days before the final test. The *Equal* group had a fifteen-minute practice-period five days before the final test. Thus, while the *Reducing* group had five minutes of practice two days before the final test, which the *Equal* group did not have, if we count back as far as five days before the final test, the *Equal* group had two and one-half minutes more practice in closing than had the *Reducing* group.

This same sort of comparison holds true in the case of the sixth grade pupils. Here the *Reducing* group had five minutes of practice twenty-four hours before the final test, which the *Equal* group did not have. Within the last two days preceding the final test, however, the *Equal* group had twenty minutes of practice, while the *Reducing* group had but twelve and one-half minutes. If the last *five* days before the final test are counted, the two groups each had an equal amount of practice, while, if we count in *one more day*, the *Equal* group had ten minutes more practice in the closing exercises than the *Reducing* group.

Just how much influence may be due to such numerical differences in *recency of the last practice before the final test* cannot be satisfactorily determined, for, as yet, the mathematics of the curve of forgetting is problematical, to say the least.

Number of practice-periods. In the geography experiment with seventh grade pupils the *Equal* group had eight practice-periods in all, the *Reducing* group had eleven. In the geography and history experiments with sixth grade pupils the *Equal* groups had six

practice-periods and the *Reducing* groups ten. The *Reducing* groups thus had approximately one-third more practice-periods than the *Equal* groups. This may be construed as an advantage in favor of the *Reducing* groups, since most investigations seem to show that any given amount of practice is more effective when distributed in a larger number of periods, providing, of course, that the periods are not made too short, i. e., unreasonably short.

Interval between practice-periods. Assuming that both schedules are spread over the same total length of time, the interval between periods becomes a direct corollary of the *number of periods*, i. e., the more practice-periods there are, the shorter must necessarily be the average length of the intervals between. In our experiments, the time-interval for the *Equal* schedule varied from two to five days, with an average length of eighty-nine hours in the case of the seventh grade experiment and an average of seventy-two hours in the case of the sixth grade experiments. With the *Reducing* schedule the variation was from one to five days, with an average of sixty-two hours for the seventh grade experiment and forty hours for the sixth grade experiments. It should be noted in this connection that at least a three-day interval, over the week-end, is unavoidable in experiments with public school children.

Summing up the experiments with geography and history, the *Reducing* schedule shows notably better results. No sure conclusions concerning the reasons for this superiority can be drawn, owing to the various factors entering in, many of which could not be very rigorously controlled. With such a large margin of variability in the results thus far considered, it would certainly be far from conservative to attribute the advantage in favor of the *Reducing* schedule to the difference in the length of the practice-periods, or the intervals between practice-periods, alone.

(*b*) *Single-column addition.* Classes 'a' to 'k' inclusive practised with single-column addition according to the time-schedule shown in Table IV. The bonds here exercised were, presumably, much older than those exercised in the case of geography and history and may, therefore, be considered as fairly well established. Assuming the learning curve to be parabolic in form, the older the bonds are, the less is the amount of improvement that may be expected from a given amount of practice: hence, if it were possible to compare the results obtained from the practice in geography with those obtained

from the practice in addition, we should expect the greater improvement to be shown in the case of the subject representing the newer bonds, viz., geography.

In view of the fact that some of the above-mentioned classes contained pupils in both halves of the grade, it was decided to combine the results for the entire third and fourth grades. This procedure may be further justified because of the larger number of cases we are thus enabled to include in the two groups which are to be compared. We have, then, for the *Equal* group, classes 'e, f, g, h, i' and 'j', containing 56 third grade pupils and 119 fourth grade pupils, or a total of 175. The *Reducing* group includes classes 'a, b, c, d' and 'k' and contains 94 third grade pupils and 59 fourth grade pupils, or a total of 153. The results of this experiment, which was carried out from November 2 to December 18, 1914, show approximately the same amount of gross gain for both groups. The facts appear in Table X.

TABLE X

COMPARISON OF RESULTS OF *Equal* AND *Reducing* GROUPS IN THE CASE OF SINGLE-COLUMN ADDITION

Time Dist.	No. of Pupils	Ave. Age	Ave. No. Correct in Init. Test	Ave. Gross Gain in No. Correct	Per Cent in Init. Test Correct, of Problems Attempted	Loss or Gain in Per Cent Correct
Equal	175	9.22	12.69	6.07	59.86	Loss 1.27
Reduc.	153	9.65	11.25	6.10	52.92	Gain 6.94

Factors conditioning improvement. Among the factors conditioning improvement, the factors of the teacher, the time of day, physical and physiological conditions, etc., need not be discussed again, since both the *Equal* and the *Reducing* groups were influenced alike in these respects.

Age. The average age of the *Reducing* group is .43 of a year more than that of the *Equal* group, notwithstanding the fact that the *Equal* group contained a much larger per cent of fourth grade pupils. This fact, no doubt, constitutes an advantage in favor of the *Equal* group, since the lower the average age of pupils in any given grade, the brighter they are, as a rule. A further investigation in this

particular case showed that the higher average age of the *Reducing* group was largely due to the presence of a number of 'repeaters' in one of the third grade classes belonging to this group. The following comparison of this class with the entire group of 150 third grade pupils, in respect to age-distribution, illustrates the point in question.

Age	7	8	9	10	11	12	13	14	15	Med. Age	Ave. Age
Class 'b'	0	4	9	8	6	6	1	1	1	10.12	10.36
150 3rd Gr.	12	52	38	27	10	6	3	1	1	8.79	9.00

These facts, (1) that the *Equal* group contained sixty-eight per cent of fourth grade pupils, as against but thirty-nine per cent of fourth grade pupils in the *Reducing* group, and (2) that the average age of the *Reducing* group was practically a half year older than that of the *Equal* (this being due largely to the presence of retarded pupils in the *Reducing* group), both tended to favor the *Equal* group.

Initial ability. The initial ability of the two groups was approximately the same, the facts appearing as follows:

AVERAGE INITIAL SCORES

Subject	Grade	*Equal* Group	*Reducing* Group
Addition	3rd, 4th	12.69 (No. P. 175)	11.25 (No. P. 153)

Assuming a slight positive correlation between initial scores and amount of improvement in any given function, the higher average score made by the *Equal* group in the initial test would mean a slight additional advantage for this group. If we eliminate this difference in initial scores by the method already adopted, viz., "The Pairing-off Method," we have the following results:

COMPARISON OF RESULTS OF THE *Equal* AND THE *Reducing* GROUPS, AFTER EQUALIZING INITIAL ABILITY BY THE METHOD OF "PAIRING OFF" THE INITIAL SCORES OF THE TWO GROUPS

Group	No. Pupils	Ave. Init. Score	Ave. Gross Gain
Equal	170, (175)	12.05 (12.69)	6.02 (6.07)
Reduc.	143, (153)	12.02 (11.25)	6.25 (6.10)

The above equalization of the two groups in respect to initial score does not affect the average age to any noticeable extent.

The result is to reduce the average age of the *Equal* group by but .01 of a year and to increase the average age of the *Reducing* group by the same trifle.

Recency of the last practice before the final test. All of the classes composing the *Equal* group, except class 'i', had the 100 minutes of practice preceding the final test spread over the period of time from November 2 to November 24, on which date all of the pupils in both groups were given an intermediate test. After this date the *Equal* group had no further practice until the final test on December 18. Class 'i' began on the day of the intermediate test and had its 100 minutes of practice distributed between this date and the date of the final test.

The classes composing the *Reducing* group had eighty minutes of practice spread over the period of time from November 2 to November 24. Between this date and the final test all of these classes, except class 'k', were given the other twenty minutes of their practice, the last two and one-half minutes of which occurred two days before the final test. Class 'k', because of a change in plan, was given no further practice until the final test, hence this class was short twenty minutes in the total amount of practice as compared with all the other classes taking part in the experiment.

A comparison of the scores made in the intermediate test on November 24 with those made in the final test on December 18 reveals marked differences between classes, in the amount of forgetting that took place during the interim between the two tests, in the case of those classes which had *no practice* during this time. Similar differences in respect to the amount of improvement that took place also appear between those classes which *continued to practice* during this time. Some of the classes which had no practice during this interim made higher scores in the final test than in the intermediate test, while some of the classes which continued to practice during this interim made higher scores in the intermediate test than in the final test. Differences in the amount of practice done outside of the experiment, or differences in response to general school training may account, in part, for such discrepancies, but the probability is that most of these irregularities are due to chance variation.

(*c*) *Short division.* The very large per cent of improvement made by the classes in division was, no doubt, partly due to the novel arrangement of the examples. For any such novel arrangement of test material obviously operates to produce a lower initial score than otherwise might be made. The lower initial score, together with the rapid improvement, due to the ease of overcoming the novelty in the arrangement of the material, and the consequent higher score in the final test, all tend to produce a very great amount of improvement as a result of a relatively small amount of practice. Then, too, the practice curve for division in the case of our pupils was probably not as far advanced as the curve for addition. This would seem evident from the fact, (1) that pupils ordinarily learn addition before they learn division, and (2) that most pupils have occasion to use addition more than they do division. Hence, in so far as the curve of learning is parabolic in form, the improvement would be more rapid in the case of that function which has been practised least—in this case, division.

In conducting the experiment in short division the same general plan was followed as in the experiment with addition described above. The initial test was given on November 2, the intermediate test on November 24, and the final test was given on December 18, 1914. Classes 'n' and 'o' followed the *Equal* schedule and classes 'l' and 'm' followed the *Reducing* schedule, as shown in Table IV. The *Reducing* group made approximately one-ninth more gain than the *Equal*. These facts appear in Table XI.

TABLE XI

COMPARISON OF RESULTS OF THE *Equal* AND *Reducing* GROUPS, IN THE CASE OF SHORT DIVISION

Time Dist.	No. of Pupils	Average Age	Ave. No. Correct in Init. Test	Ave. Gross Gain in No. Correct	Per Cent in Init. Test Correct, of Problems Attempted	Gain in Per Cent Correct
Equal	56	11.45	65.98	64.66	87.54	6.57
Reduc.	71	11.23	70.04	71.42	85.00	7.86

Having already discussed the common factors influencing improvement in our experiment, only those need be treated again whose variation is peculiar to the groups now being compared.

Age. In this comparison the average age of the *Equal* group is .22 of a year higher than that for the *Reducing* group. This difference was partly due to the fact that the classes composing the *Equal* group contained a larger per cent of pupils in the upper half of the grade. This may be considered as a slight advantage in favor of the *Equal* group, since the higher average age of this group was not due to the presence of retarded pupils as was the case in the comparison of the two groups made up of third and fourth grade pupils. (*cf.* p. 35 above.)

Initial ability. The initial average score made by the *Reducing* group was approximately six per cent higher than that made by the *Equal* group. Assuming a slight positive correlation between initial score and improvement, this would constitute a slight advantage in favor of the *Reducing* group. If this assumption is true, then, by equalizing the initial ability of the two groups by the method employed in previous comparisons, we should expect the greater gain shown for the *Reducing* group to be somewhat reduced. This is what happens, for by eliminating the higher scores made by the *Reducing* group, thus equalizing the average scores, for the two groups, the average gross gain for the *Reducing* group is reduced from 71.42 to 69.40. Thus the gain of the *Reducing* over the *Equal* group is reduced, approximately, from one-tenth to one-twentieth. Again, if we equalize the initial ability of the two groups by eliminating the highest two scores from the *Reducing* group and the lowest scores from the *Equal* group, we find that the average gross gain for the *Reducing* group is reduced from 71.42 to 69.88, while that for the *Equal* group is increased from 64.66 to 68.18. This reduces the margin shown in favor of the *Reducing* group to 1.7, or approximately two and one-half per cent of the average gross gain.

Recency of last practice preceding the final test. The *Equal* group had no practice from the intermediate test on November 24 to the final test on December 18. The *Reducing* group had twenty minutes of practice distributed over the interim between these two dates, with two and one-half minutes of this amount occurring two days before the final test. On the basis of general theory, therefore, this arrangement would be calculated to favor the *Reducing* group. A

comparison of the records made in the intermediate test with those made in the final test, however, seems to indicate that the *Equal* group did not suffer because of this lack of recency of practice. Such discrepancies between expectation based on general theory, and results obtained in experiments of this kind, may be due to differences in the amount of outside practice done by the two groups, or other factors which were beyond our control. In all probability, however, these and many other conflicting results occurring in similar experiments are due as much to chance variation as to any other single factor. Such irregularities can only be smoothed out by the use of a large number of subjects, running well into the thousands.

Summing up all the Lyndhurst experiments, the results seem to point toward a slight superiority in the arrangement of the *Reducing* schedule, though this superiority is by no means marked. The following section contains an account of the repetition of the same experiment with school children in another state.

SECTION III

THE OHIO EXPERIMENTS

I. DESCRIPTION

The experimental work reported in this section was done during the fall of 1915, in the following seven villages of Northwest Ohio, viz., Rocky Ridge, Lakeside, Elmore, and Oak Harbor, in Ottawa County; Greenwich, in Huron County; Waterville, in Lucas County, and Weston, in Wood County. These were all typical rural villages for this section of the country, with the exception of Lakeside, which is a summer resort. The school population of this last-named place, however, is made up of the permanent residents of the village.

CHARACTER OF THE SCHOOL POPULATION

The *nationality* of the pupils in the public schools of all the seven villages taken together would average about seventy-five per cent American born. Because of the lack of general educational opportunity, however, they would not, upon the whole, rank above the Lyndhurst pupils in the use of the English language. In respect to *economic conditions*, there appeared to be greater extremes of both wealth and poverty than was noted at Lyndhurst. The general *educational conditions*, including school plant and equipment, averaged about the same, though with poorer buildings in some of the Ohio villages than any found in Lyndhurst or Rutherford. In respect to supervision and teaching force the comparison was very favorable.

SUBJECTS USED IN THE EXPERIMENT

The subjects used in the Ohio experiments consisted of all the pupils in grades three to eight, inclusive. Table XII shows the distribution of pupils by villages and by grades.

TABLE XII

DISTRIBUTION OF THE PUPILS USED IN THE OHIO EXPERIMENTS, BY VILLAGES AND BY GRADES

Villages	Grades						*Total*
	3	4	5	6	7	8	
Rocky Ridge	10	7	13	9	7	11	*57*
Elmore	22	20	15	22	..	..	*79*
Lakeside	9	13	15	15	10	17	*79*
Greenwich	27	11	13	23	12	11	*97*
Waterville	25	17	13	23	21	16	*115*
Weston	33	20	20	21	29	18	*141*
Oak Harbor	37	(44)	33	28	32	43	*217*
Totals	*163*	*132*	*122*	*141*	*111*	*116*	*785*

The absence of any data for the seventh and eighth grades of the Elmore school is due to a misunderstanding on the part of the teacher of these grades with reference to the handling of the initial test papers, resulting in the loss of these records. In order to provide a comparison of Ohio pupils with Lyndhurst pupils, in division, the forty-four fourth grade pupils of the Oak Harbor school were practised with short division. With this exception, all the third and fourth grade pupils were practised with adding, the fifth and eighth grades learned geographical facts, and the sixth and seventh grades learned historical facts.

About 1,000 pupils in all entered into the experiment, but owing to illness, bad weather, and other causes, a number of the records were incomplete. After making all necessary eliminations, there were 785 records that could be used in our study.

CONTENT-MATERIAL USED

The material used in the Ohio experiments was identical with that used at Lyndhurst, viz., geography, history, addition, and short division. For a description of this material the reader is referred to a corresponding paragraph in Section II.

PLAN OF THE EXPERIMENT

In planning the time schedule, the same general principle was followed as in previous experiments, viz., to compare the effect of

two sorts of distribution, designated as the *Equal* and the *Reducing*. In this case, the *Equal* schedule consisted of eight practice-periods of fifteen minutes each (except the last but one, which was ten minutes) occurring, in so far as possible, on Mondays, Wednesdays, and Fridays. The *Reducing* schedule consisted of eleven practice-periods, distributed over approximately the same period of time, and apportioned as follows: 15, 15, 15, 12½, 10, 10, 7½, 7½, 5, 2½ and the final test of 15 minutes. By this arrangement, each of the two schedules has a total of 115 minutes. The initial and final scores were counted as the average, or mid-point, of the first and last fifteen minutes of practice, respectively, hence the amount of practice that was measured was 100 minutes—the same as in the Lyndhurst experiments.

Owing to the impossibility of reaching more than one of the villages on the same day, it was necessary to begin the experiment in each village on a different day, also, to give the final tests on different days. (There was one exception to this, since it was possible to reach two of the places, viz., Rocky Ridge and Lakeside, during school hours of the same day.)

Table XIII gives the exact dates on which the work was done in each of the seven villages. The general plan was to have the final tests occur several days before the beginning of the Christmas holidays.

TABLE XIII

DATES ON WHICH THE EXPERIMENT WAS CARRIED OUT IN EACH OF THE SEVEN VILLAGES

The figures in the body of the table represent the length of each practice-period in minutes. All the classes at Rocky Ridge, Lakeside, and Greenwich, together with grades 6 and 8 from Oak Harbor, followed the *Equal* schedule. Grades 3, 5, and 7 from Oak Harbor and all the classes at Elmore, Waterville, and Weston followed the *Reducing* schedule.

		Equal-schedule Classes			*Reducing*-schedule Classes				
1915 Nov.		Rocky Ridge	Lake-side	Green-wich	Oak Harbor		El-more	Water-ville	Wes-ton
T	16	..	..	..	..	..	15	..	..
W	17	..	..	..	15	15	..	..	..
T	18	15	15	..	..	15	15	..	..
F	19	..	..	15	15	15	15	..	..
S	20	..	..	..	..	..	..	..	..
S	21	..	..	..	..	..	..	..	..
M	22	15	15	15	15	12½	12½	..	..
T	23	..	..	..	..	10	10	..	..
W	24	15	15	15	15	10	10	..	..
T	25	..	..	..	..	..	..	..	..
F	26	..	..	..	..	..	..	..	..
S	27	..	..	..	..	..	..	..	..
S	28	..	..	..	..	..	..	..	..
M	29	15	15	15	15	7½	7½	15	15
T	30	..	..	..	..	..	7½	15	15
W	1	15	15	15	15	7½	5	15	15
T	2	..	..	..	..	..	..	12½	12½
F	3	15	15	15	10	5	2½	10	10
S	4	..	..	..	..	..	..	..	..
S	5	..	..	..	..	..	..	..	..
M	6	10	10	10	..	2½	15	10	10
T	7	..	..	..	..	..	..	7½	7½
W	8	..	..	..	15	15	..	7½	7½
T	9	15	15	..	..	..	..	5	..
F	10	..	..	15	..	..	..	2½	..
S	11	..	..	..	..	..	..	..	..
S	12	..	..	..	..	..	..	..	..
M	13	..	..	..	..	..	..	15	..
1916[1] Jan.									
T	6	..	..	..	..	..	..	..	5
F	7	..	..	..	..	..	..	..	2½
S	8	..	..	..	..	..	..	..	..
S	9	..	..	..	..	..	..	..	..
M	10	..	..	..	..	..	..	..	15

[1] On account of a fear of an epidemic of scarlet fever, the school at Weston was closed before the experiment was completed. The completion practice and the final test for this school, therefore, were given as soon as school reconvened in January.

ADMINISTRATION OF THE EXPERIMENT

All the initial and final tests were conducted by the author at the time most convenient for him. The daily practice, however, was in charge of the regular teachers and was done at the time of day most convenient for them. Thus, in the arrangement of the time schedules for the two groups, the factor of the time of day was distributed at random.

Method of conducting the practice. In order that all the practice might be conducted as uniformly as possible, each teacher was provided with a set of instructions. The author was able to visit each village once or twice a week and thus checked up the work of both teacher and pupils. The instructions placed in the hands of the teachers were simple and very brief. First of all was a copy of the time schedule which was to be followed. Then came the following directions: "The teacher will simply follow the example set by the experimenter in giving the initial test. N.B. *All* the time allotted to each practice-period shall be used in *practice*, in the case of addition, or in *study* and *testing*, in the case of geography and history. No individual help is to be given any of the pupils. In general, no questions are to be answered. The idea is for each pupil to strive to improve upon his, or her, own record made at the previous time. The pupils are not to see or handle the papers, except during the regular practice-periods, as provided for in the time schedule."

Instead of suggesting difficulties by attempting to explain them beforehand, such problems were left to be dealt with whenever they might arise. Few such difficulties arose, however, and such as did arise were disposed of without any undue interruption of the main purpose of the experiment.

The incentives used were the same as those used in the Lyndhurst experiments, with the exception that no material rewards were offered. The teachers were instructed to conduct the practice in their accustomed manner, so far as incentives were concerned. In a word, it was our purpose to have the practice in these experiments done as nearly as possible under the same conditions that prevail in the regular work of the school year. That this result was actually achieved, is borne out by the fact that among the individual records of the pupils were found not only marks of improvement, but also the usual per cent of failures to profit by the practice.

SCORING AND TABULATING THE RESULTS

The same method of scoring was used as in the Lyndhurst experiments. The daily scores made in addition and, in so far as possible, in geography and history, were kept by the teachers. The superintendents, with but two exceptions, did the tabulating of the daily scores. The tabulating for the Greenwich school was done by Mr. Craig, a teacher in a nearby consolidated rural school. In the case of the Oak Harbor school, the tabulating was done by Miss Ingle, one of the teachers in the high school of that village. The author is responsible for checking the work done by the teachers and superintendents and for the statistical treatment of the data.

2. RESULTS OF THE EXPERIMENTS

Table XIV gives the distribution of scores made in the initial test. Table XV gives the distribution of the per cent of problems attempted that were solved correctly. Table XVI gives the distribution of the changes that took place in the number of problems solved correctly, during the 100 minutes of practice. Table XVII gives the distribution of the changes in the per cent of accuracy.

TABLE XIV

INITIAL ABILITY IN THE OHIO EXPERIMENTS:
FREQUENCIES FOR INITIAL SCORE

The figures at the top represent the number of problems solved correctly in the initial test of 15 minutes.

The table reads as follows: Of the 39 eighth grade pupils who learned geographical facts according to the *Equal* schedule, there were none who made scores of 0, plus 1, 2, 3, or 4; 1 made a score of 5, 6, 7, 8, or 9; 10 made scores of 10, 11, 12, 13, 14; etc.

Time Dist.	No. of Pupils	Grade	Materials Used	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64
Equal	39	8	Geog.	..	1	10	7	6	7	4	4	..	..	..	..	..
Reduc.	77	8	Geog.	10	3	3	11	15	10	8	6	4	4	1	1	1
Equal	61	7	Hist.	..	11	15	18	11	2	4	..	..	..	..	..	..
Reduc.	50	7	Hist.	12	7	9	1	6	5	5	2	1	..	..	2	..
Equal	47	6	Hist.	3	13	17	14	..	..	..	..	..	..	..	..	..
Reduc.	94	6	Hist.	1	17	28	24	12	8	1	2	..	1	..	..	..
Equal	74	5	Geog.	8	16	21	11	6	6	2	2	1	1	..	..	..
Reduc.	48	5	Geog.	1	25	16	5	1	..	..	..	..	..	..	..	..
Equal	114	3, 4	Add.	41	23	29	12	3	4	2	..	..	..	..	..	..
Reduc.	137	3, 4	Add.	44	38	23	17	9	3	..	1	..	..	2	..	..

TABLE XV

INITIAL ABILITY IN THE OHIO EXPERIMENTS: FREQUENCIES FOR PER CENT OF ACCURACY

The figures at the top represent the per cent of problems attempted that were correctly solved in the initial test.

The table reads as follows: Of the 39 eighth grade pupils who learned geographical facts according to the *Equal* schedule, there were none who showed as low a per cent of accuracy as 0, 1, 2 ..... 14 per cent; 1 fell as low as 15, 16, 17, 18, or 19 per cent; but no others fell within the range of 20, 21, 22 .....29 per cent; 3 showed an accuracy of 30, 31, 32, 33, or 34 per cent; etc.

Time Dist.	No. of Pupils	Grade	Materials Used	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39	40 44
Equal	39	8	Geog.	..	..	..	1	...	...	3	...	1
Reduc.	77	8	Geog.	2	..	1	..	2	1	1	...	2
Equal	61	7	Hist.	..	1	1	1	...	...	1	2	...
Reduc.	50	7	Hist.	..	..	..	1	3	...	3	1	4
Equal	47	6	Hist.	..	..	..	..	1	...	2	2	...
Reduc.	94	6	Hist.	..	..	1	..	1	...	2	3	3
Equal	74	5	Geog.	1	..	3	2	1	2	3	4	6
Reduc.	48	5	Geog.	..	..	..	3	4	5	7	4	1
Equal	114	3, 4	Add.	12	2	4	4	4	5	6	3	9
Reduc.	137	3, 4	Add.	13	3	5	7	5	9	5	9	10

(Above Table continued)

Time Dist.	45 49	50 54	55 59	60 64	65 69	70 74	75 79	80 84	85 89	90 94	95 99	100
Equal	4	5	4	4	4	3	3	2	2	2	1	1
Reduc.	4	6	1	13	5	10	11	8	5	4	...	1
Equal	1	2	..	1	2	3	8	7	8	13	6	4
Reduc.	3	3	5	2	3	6	3	2	3	2	1	5
Equal	2	1	2	10	6	4	5	5	1	5	...	1
Reduc.	5	5	3	11	10	8	8	14	4	8	2	6
Equal	1	4	8	6	5	7	10	4	3	2	1	1
Reduc.	2	5	3	5	1	4	2	...	1	...	...	1
Equal	3	14	4	3	8	9	3	2	7	4	...	5
Reduc.	8	12	4	5	5	9	14	3	2	7	1	1

TABLE XVI

AMOUNT OF IMPROVEMENT IN THE OHIO EXPERIMENTS: NUMBER OF PROBLEMS SOLVED CORRECTLY

The figures at the top represent the amount of improvement, plus or minus, that took place during the time of the experiment, in the number of problems solved correctly in 15 minutes.

The table reads as follows: Of the 39 eighth grade pupils who learned geographical facts according to the *Equal* schedule, there were none who showed an improvement of minus 20, 19, 18 ..... 1; none showed an improvement of 0, plus 1, 2, 3 .....9; 1 made an improvement of 10, 11, 12, 13, or 14; 3 made an improvement of 15, 16, 17, 18, or 19; etc.

Time Dist.	No. of Pupils	Grade	Materials Used	−20 16	−15 11	−10 6	−5 1	0 4	5 9	10 14	15 19	20 24	25 29
Equal	39	8	Geog.	..	..	..	..	..	..	1	3	2	1
Reduc.	77	8	Geog.	..	..	..	..	..	..	2	4	11	3
Equal	61	7	Hist.	1	..	2	..	..	1	..	7	6	6
Reduc.	50	7	Hist.	..	..	..	..	..	1	4	5	4	8
Equal	47	6	Hist.	..	..	..	1	1	3	3	5	8	7
Reduc.	94	6	Hist.	..	..	..	..	1	..	5	3	12	6
Equal	74	5	Geog.	..	..	1	5	10	5	4	6	6	7
Reduc.	48	5	Geog.	..	..	..	..	1	..	4	5	7	8
Equal	114	3, 4	Add.	..	3	12	23	39	21	8	2	5	..
Reduc.	137	3, 4	Add.	..	2	6	23	43	27	12	9	3	3

(*Above Table continued*)

Time Dist.	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 74	75 79	80 84	85 89	90 up
Equal	3	..	4	7	7	4	..	...	2	2	1	1	1
Reduc.	6	3	7	5	10	5	7	3	3	1	3	1	3
Equal	8	8	5	4	7	2	2	...	2	...	...	...	...
Reduc.	4	4	12	3	3	1	..	...	1	...	...	...	...
Equal	4	4	5	3	2	1	..	...	...	...	...	...	...
Reduc.	14	17	17	9	7	2	1	...	...	...	...	...	...
Equal	7	7	7	3	5	..	..	...	...	...	...	...	1
Reduc.	10	5	6	2	..	..	..	...	...	...	...	...	...
Equal	..	1	..	..	..	..	..	...	...	...	...	...	...
Reduc.	4	1	..	2	..	..	..	2	...	...	...	...	...

TABLE XVII

AMOUNT OF IMPROVEMENT IN THE OHIO EXPERIMENTS: PER CENT CORRECT

The figures at the top represent the amount of improvement, plus or minus, in the per cent of problems attempted that was correctly solved, that took place during the time of the experiment. The table reads as follows: Of the 39 eighth grade pupils who learned geographical facts according to the *Equal* schedule, there were none who showed an improvement in accuracy of minus 85, 84, 83 ..... 16 per cent; 1 showed an improvement of minus 15, 14, 13, 12, or 11 per cent; none showed minus 10, 9, 8, 7, or 6 per cent; 1 showed minus 5, 4, 3, 2, or 1 per cent; 3 showed 0, plus 1, 2, 3, or 4 per cent; etc.

Time Dist.	No. of Pupils	Grade	Material	Less than −46	−45 41	−40 36	−35 31	−30 26	−25 21	−20 16	−15 11	−10 6	−5 1
Equal	39	8	Geog.	..	..	..	..	..	..	..	1	..	1
Reduc.	77	8	Geog.	..	..	..	..	..	2	..	..	..	..
Equal	61	7	Hist.	2	1	..	2	..	2	1	..	2	1
Reduc.	50	7	Hist.	..	..	..	..	..	..	..	..	..	1
Equal	47	6	Hist.	..	1	..	..	..	..	2	2	3	..
Reduc.	94	6	Hist.	..	..	..	..	..	..	1	1	5	1
Equal	74	5	Geog.	1	1	1	..	1	1	1	1	3	8
Reduc.	48	5	Geog.	..	..	..	..	..	1	..	..	1	..
Equal	114	3,4	Add.	2	2	5	4	8	3	8	6	7	11
Reduc.	137	3,4	Add.	3	2	1	3	6	6	4	11	8	11

(*Above Table continued*)

Time Dist.	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 up
Equal	3	6	2	4	3	1	7	3	5	..	3	..	..	..	..
Reduc.	2	7	12	8	13	7	6	4	5	3	2	2	..	1	3
Equal	2	11	4	6	6	4	8	4	2	1	2	..	..	..	..
Reduc.	5	3	6	..	5	5	2	3	4	4	2	4	3	1	2
Equal	5	2	4	2	7	3	8	2	2	2	..	..	2	..	..
Reduc.	8	8	10	13	4	10	9	9	4	6	1	2	2	..	..
Equal	6	6	7	9	6	6	4	4	1	..	5	1	..	..	1
Reduc.	1	1	2	2	3	6	3	4	9	6	6	..	1	..	2
Equal	8	4	7	7	9	2	11	3	1	1	..	3	1	..	1
Reduc.	7	11	11	5	4	10	9	6	7	1	2	4	2	1	2

The *Equal* and the *Reducing* groups were made up from the pupils of the seven villages as follows: The *Equal* group included all the classes at Rocky Ridge, Lakeside, and Greenwich, and grades 3, 5, and 7 from Oak Harbor. The *Reducing* group included grades 6 and 8 from Oak Harbor and all the classes at Elmore, Waterville, and Weston.

The third and fourth grades (except the fourth grade at Oak Harbor) practiced with single-column addition. The fifth and eighth grades learned geographical facts, and the sixth and seventh grades learned historical facts. The material used and the amount of practice measured were the same as in the case of the Lyndhurst experiments.

The results of the geography and history experiments were influenced in the same way, though not to so great an extent, as at Lyndhurst, i. e., by a little preliminary study before the initial test. Thus there was in the initial test a slight immediate memory element, which tended to make the initial score higher than it otherwise would have been. In no case, however, was there any practice immediately preceding the final test. This precluded any immediate memory effect on the final score and operated to make the amount of gain shown more conservative. It should be understood in this connection that the influence here mentioned does not in any way affect the comparison of the two schedules of distribution of practice, but only affects the *amount* of improvement shown as a result of the 100 minutes of practice.

The results of these experiments show that in the case of the third, fourth, fifth, and sixth grades, the *Reducing* groups made more improvement. In the case of the seventh and eighth grades the *Equal* groups did better. Table XVIII gives the complete facts.

TABLE XVIII

COMPARISON OF THE RESULTS OF THE *Equal* AND THE *Reducing* GROUPS, GRADE BY GRADE

Time Dist.	No. of Pupils	Grade	Material Used	Average Age	Ave. No. Correct in Init. Test	Ave. Gross Gain in No. Correct	Per Cent in Init. Test Correct of Problems Attempted	Gain in Per Cent Correct
Equal	39	8	Geog.	13.69	21.65	53.02	65.77	29.38
Reduc.	77	8	Geog.	13.64	24.25	48.57	65.20	25.85
Equal	61	7	Hist.	12.93	16.52	34.48	65.67	12.56
Reduc.	50	7	Hist.	12.78	17.34	32.70	62.98	32.68
Equal	47	6	Hist.	12.09	11.66	28.07	67.15	16.27
Reduc.	94	6	Hist.	11.77	15.91	35.22	69.55	22.00
Equal	74	5	Geog.	10.96	14.74	24.90	57.93	14.14
Reduc.	48	5	Geog.	11.09	9.96	28.63	45.81	34.82
Equal	114	3, 4	Add.	8.92	8.90	5.70	43.28	5.90
Reduc.	137	3, 4	Add.	9.07	9.47	7.07	45.85	8.95

FACTORS CONDITIONING IMPROVEMENT

The factor of the *teacher* was equalized by a random selection of the classes which made up the two groups.

The *hour of the day* at which the practice was done was determined by the individual teachers, and was thus as likely to favor one group as the other. It should be stated, however, that, having selected a suitable hour of the day, each teacher maintained this hour throughout the experiment.

It is not at all certain that the pupils in the different villages had had the same amount of *previous training*, grade for grade, in the subjects used. Yet, the random method of selecting the pupils would tend to favor one group as much as the other, in so far as this factor was concerned.

No exceptional cases of *mental attitude* were noticed in any of the schools, which might have unduly influenced either group.

The *physical conditions*, such as light, heat, ventilation, seating arrangement of the pupils, etc., differed very greatly among the

several schools. Each group, however, contained some of the poorest and some of the best conditions of this sort. The school building at Oak Harbor was the only modern building found, hence some of the classes in this school were included in each of the two groups. (*cf.* Table XIII.)

Conditions of *health* influenced the work of the pupils in practically all of the schools. The time of the experiments happened to be an exceptionally bad season for epidemics of scarlet fever, measles, whooping cough, and the like. The records of pupils thus affected, however, were necessarily eliminated on account of incompleteness, except in the case of the Weston school, which was closed as a precautionary measure against the scarlet fever about a week before our experiment was concluded. The pupils of this school returned, however, in good condition immediately after the holidays, at which time the experiment was again taken up and finished.

The factors of *interest and worry* varied from week to week and with the different schools. The influence of such factors cannot be measured or rated in any satisfactory way, but, upon the whole, we should say, the pupils in all the schools manifested the ordinary amount of interest in the tasks assigned them and appeared as carefree as any ordinary school children.

There is a very close correspondence between the two groups in respect to *average age*, in all the comparisons made. The largest difference in any instance is that of the sixth grade, in which the *Equal* group shows an average age of .32 of a year more than the *Reducing* group. This difference may be due, in part at least, to the slower progress made by the pupils in the schools at Rocky Ridge and Lakeside, which two schools happened to fall in the *Equal* group. The slower progress of the pupils of these schools may be accounted for by the fact that many of them are kept out of school for a considerable time during the fall season, in order to help harvest the apple crop. It will be noticed that in the case of the seventh and eighth grades, also, the *Equal* groups are slightly older than the *Reducing* groups.

In four out of the five comparisons the *Reducing* groups show slightly higher *initial scores* than the *Equal* groups, but, on the whole, the two groups are substantially equal in this respect. The facts appear as follows:

AVERAGE INITIAL SCORES

Subject	Grade	*Equal* Group	*Reducing* Group
Geography	8	21.65 (No. P. 39)	24.25 (No. P. 77)
History	7	16.52 (No. P. 61)	17.34 (No. P. 50)
History	6	11.66 (No. P. 47)	15.91 (No. P. 94)
Geography	5	14.74 (No. P. 74)	9.96 (No. P. 48)
Addition	3, 4	8.90 (No. P. 114)	9.47 (No. P. 137)

By the application of the "pairing off" method, described on a previous page, for the equalization of the initial ability of the two groups, we obtain the following results:

COMPARISON OF RESULTS OF THE *Equal* AND THE *Reducing* GROUPS, AFTER EQUALIZING INITIAL ABILITY BY THE METHOD OF "PAIRING OFF" THE INITIAL SCORES OF THE TWO GROUPS

Group	Grade	Material	No. of Pupils	Initial Score	Gross Gain
Equal	8	Geog.	39 (39)	21.65 (21.65)	53.02 (53.02)
Reduc.	8	Geog.	61 (77)	21.75 (24.25)	50.23 (48.57)
Equal	7	Hist.	61 (61)	16.52 (16.52)	34.48 (34.48)
Reduc.	7	Hist.	49 (50)	16.51 (17.34)	32.78 (32.70)
Equal	6	Hist.	44 (47)	12.07 (11.66)	28.86 (28.07)
Reduc.	6	Hist.	70 (94)	12.44 (15.91)	35.60 (35.22)
Equal	5	Geog.	57 (74)	10.25 (14.74)	21.35 (24.90)
Reduc.	5	Geog.	48 (48)	9.96 (9.96)	28.63 (28.63)
Equal	3, 4	Add.	114 (114)	8.90 (8.90)	5.70 (5.70)
Reduc.	3, 4	Add.	135 (137)	8.87 (9.47)	6.34 (7.07)

If the results thus obtained are compared with those given in Table XVIII, it will be seen that the equalization of initial ability, upon the whole, increases the advantage shown in favor of the *Reducing* groups. Combining the results, we have, as a net result of equalizing the initial ability of the two groups, a gain of 7.71 per cent on the initial score for the *Equal* group and a gain of 23.06 per cent on the initial score for the *Reducing* group. All in all, the gross gain made by the *Reducing* groups is about one-fourteenth more than that made by the *Equal* groups.

In respect to *recency of last practice before the final test*, the two groups were about equally favored.

The *Equal* groups had eight *practice-periods* and the *Reducing* groups had eleven, spread over approximately the same total length of time. The average interval between periods would, therefore, necessarily be shorter in the case of the *Reducing* groups. Compare, in this connection, the paragraph on "Plan of the Experiment," and the discussion on "Number of Practice-periods," above.

Summarizing the data contained in Table XVIII, we have the following comparison as a basis for predicting what might be expected from an extended series of similar experiments.

SUMMARY OF AVERAGE GROSS GAIN IN THE NUMBER OF PROBLEMS CORRECTLY SOLVED, OR WORDS CORRECTLY SUPPLIED

Material	Grade	*Equal* Groups	*Reducing* Group	*Reducing/Equal*
Geography	8	53.02	48.57	92
History	7	34.48	32.70	95
History	6	28.07	35.22	1.25
Geography	5	24.90	28.63	1.15
Addition	3 and 4	5.70	7.07	1.24

From the above summary we have, as an average, *Reducing/Equal*, 1.10 with a P. E. *t.—obt. Av.* of .042. There are thus about five chances in a hundred that the results from an extended series of similar experiments would show no advantage for the *Reducing* group. The chances are about four to one that the ratio will be between 1.02 and 1.18. Or, we may say, the chances are even that the ratio will be between 1.06 and 1.14; or, again, the chances are about ninety-nine to one that the ratio will not exceed the limits of .975 and 1.225.

This difference in favor of the *Reducing* schedule of practice is probably due, in part, to the larger number of practice-periods in this schedule; and, in part, to the more intensive application on the part of the pupils in their effort to get as much done as possible, since the periods gradually become shorter and shorter as the experiment nears completion. The knowledge of a more limited time in which to work at any given task, at each succeeding period, may serve as a stimulus to bring about increased speed in 'warming up' and greater concentration throughout the period.

SECTION IV

THE EXPERIMENT WITH NORMAL SCHOOL STUDENTS

The experimental work reported in this section was done during the second semester of the school year 1915–1916, with first year students in the State Normal College of Bowling Green, Ohio, acting as subjects.

THE NATURE OF THE EXPERIMENT

The problem was to compare the results obtained from a given amount of practice (in this case, sixty minutes), when distributed according to two different schedules, previously described and designated as the *Equal* and the *Reducing*.

The *material* used was the Thorndike single-column addition sheets, which are described on page 14 above. The *subjects* were 157 first year students in the Normal College, of which number all were women except fourteen. The general *plan* of the experiment was the same as in all our previous experiments, viz., to divide the subjects into two groups and practice one group according to the *Equal* schedule and the other according to the *Reducing* schedule. It was also possible in this case to group the subjects according to their initial ability, as determined by the record made in the first ten minutes of practice.

There were 170 students who entered the experiment, but only 157 of the records were complete enough to count. The arrangements of the time schedule, together with the exact dates on which the practice was done, are shown in Table XIX.

Administration of the experiment. The students met in four regular class sections on Mondays, Wednesdays, and Fridays at 8:00, 9:00 and 10:00 o'clock a. m., and 2:00 o'clock p. m., respectively. The initial test was given at the regular class session of each section on Friday, March 10. The papers were scored and then sorted into four groups in the following manner: The papers were first arranged

TABLE XIX

TIME SCHEDULE FOLLOWED IN THE EXPERIMENT WITH NORMAL SCHOOL STUDENTS

The figures in the body of the table represent the length of the practice-periods.

1916	*Equal* Group		*Reducing* Group	
	Sec. A	Sec. B	Sec. A	Sec. B
F Mar. 10	10	10	10	10
S Mar. 11	..	..	..	..
S Mar. 12	..	..	..	..
M Mar. 13	10	5	15	2½
T Mar. 14	..	5	..	..
W Mar. 15	..	5	10	5
T Mar. 16	10	5	..	..
F Mar. 17	..	5	7½	7½
S Mar. 18	..	..	..	..
S Mar. 19	..	..	..	..
M Mar. 20	10	5	5	10
T Mar. 21	..	5	..	..
W Mar. 22	10	5	2½	15
T Mar. 23	..	..	..	..
F Mar. 24	10	10	10	10

in order, according to the magnitude of the scores made. The paper with the highest score was placed in pile No. 1, the next highest in pile No. 2, the next in pile No. 3, the next in pile No. 4, the next in pile No. 1, and so on. The four piles of papers thus represented four groups of students with approximately equal initial ability. The papers in pile No. 1 were marked "*Equal* Group, Section A," those in pile No. 2 were marked "*Reducing* Group, Section A," those in pile No. 3 were marked "*Equal* Group, Section B," and those in pile No. 4 were marked "*Reducing* Group, Section B." The papers were returned to the students on the following day, whereupon each person could see what his initial score was and also to which practice group he had been assigned. According to previous instructions each person then proceeded to carry out the practice in adding, according to the time schedule for the group to which he had been assigned. At each regular recitation period the progress of the experiment was checked up by the author, who had charge of the course which these students were taking.

The initial and final tests were given in class, the averages being taken as the initial and final scores. The daily practice was done outside the class. The students were furnished with correct answers to the problems and were thus enabled to check up their own work after each practice-period, without receiving extra practice in adding by so doing. Each one was required to plot a graph of his work, showing the improvement made as a result of the sixty minutes of practice. A score of one was allowed for each column correctly added. The index of accuracy used was:

$$\frac{\text{Number of columns correct}}{\text{Number of columns attempted}}.$$

THE RESULTS OF THE EXPERIMENT

Table XX gives the frequencies for the number of problems solved correctly in the initial test of ten minutes. Table XXI gives the frequencies for the per cent of problems attempted that were correctly solved in the initial test. Table XXII gives the frequencies for the amount of improvement made as a result of the fifty minutes of practice that was measured, i. e., that amount of practice which lay between the average, or mid-point, of the first ten minutes of practice and the average, or mid-point, of the last ten minutes of practice.

TABLE XX

NORMAL SCHOOL EXPERIMENT: FREQUENCIES FOR INITIAL SCORE

The figures at the top represent the number of problems solved correctly in the initial test of 10 minutes.

The table reads as follows: Of the 42 subjects, who practised adding according to *Equal* schedule A, there were none who made scores as low as 10, 11, 12, 13, or 14 in the initial test; 3 made scores of 15, 16, 17, 18, or 19; 7 made scores of 20, 21, 22, 23, or 24; etc.

Group and Section	No. Subjects	10 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64
Equal— A	42	..	3	7	8	8	6	4	3	2	1	..
Equal— B	41	2	3	6	10	9	4	4	2	1	..	..
Reduc.—A	36	..	2	5	9	10	4	3	2	..	1	..
Reduc.—B	38	1	3	7	9	5	5	3	2	1	1	1
Equal A and B	83	2	6	13	18	17	10	8	5	3	1	..
Reduc. A and B	74	1	5	12	18	15	9	6	4	1	2	1

TABLE XXI

NORMAL SCHOOL EXPERIMENT: FREQUENCIES FOR ACCURACY

The figures at the top represent the per cent of problems attempted that were correctly solved in the initial test of 10 minutes.

The table reads as follows: Of the 42 subjects who practised adding according to *Equal* schedule A, there was 1 who fell as low as 40, 41, 42, 43, or 44 per cent in accuracy; none fell within the range of 45, 46 ..... 69 per cent; 3 showed 70, 71, 72, 73, or 74 per cent; none showed 75, 76, 77, 78, or 79 per cent; 8 showed an accuracy of 80, 81, 82, 83, or 84 per cent; etc.

Group and Section	No. Subjects	40 44	45 49	50 54	55 59	60 64	65 69	70 74	75 79	80 84	85 89	90 94	95 99	100
Equal— A	42	1	..	..	..	..	..	3	..	8	8	10	7	5
Equal— B	41	..	..	..	..	..	3	1	1	5	6	10	10	5
Reduc.—A	36	..	..	..	..	..	..	1	4	8	6	7	8	2
Reduc.—B	38	..	..	..	..	..	2	1	5	6	7	9	6	2
Equal A and B	83	1	..	..	..	..	3	4	1	13	14	20	17	10
Reduc. A and B	74	..	..	..	..	..	2	2	9	14	13	16	14	4

TABLE XXII

NORMAL SCHOOL EXPERIMENT: FREQUENCIES FOR IMPROVEMENT IN THE NUMBER OF PROBLEMS SOLVED CORRECTLY

The figures at the top represent the amount of improvement, plus or minus, that took place during the time of the experiment, in the number of problems solved correctly in 10 minutes.

The table reads as follows: Of the 42 subjects who practised adding according to *Equal* schedule A, there was 1 who showed an improvement of minus 10, 9, 8, 7, or 6; 1 who showed an improvement of minus 5, 4, 3, 2, or 1; 8 who showed an improvement of 0, plus 1, 2, 3, or 4; etc.

Group and Section	No. Subjects	10 6	5 1	0 4	5 9	10 14	15 19	20 24	25 29	30 34
Equal— A	42	1	1	8	12	9	9	1	1	..
Equal— B	41	..	..	12	12	10	4	2	..	1
Reduc.—A	36	..	..	10	9	7	5	4	..	1
Reduc.—B	38	..	2	7	8	8	12	1	..	..
Equal A and B	83	1	1	20	24	19	13	3	1	1
Reduc. A and B	74	..	2	17	17	15	17	5	..	1

DISCUSSION OF THE RESULTS

In this experiment both sections of the *Reducing* group made more improvement than the corresponding sections of the *Equal*

group. Combining the results of the two sections of each group and comparing the totals thus obtained, the *Reducing* group shows approximately one-fourteenth more gain than the *Equal* group. The complete facts appear in Table XXIII.

TABLE XXIII

COMPARISON OF RESULTS OF THE *Equal* AND THE *Reducing* GROUPS, IN THE EXPERIMENT WITH NORMAL SCHOOL STUDENTS

Group	No. of Subjects	Average Age	Ave. No. of Problems Correct in Init. Test	Ave. Gross Gain in No. of Problems Correct	Per Cent Correct in Init. Test	Gain in Per Cent Correct
Equal— A	42	19.22	32.76	9.74	88.40	5.00
Reduc.—A	36	20.36	31.44	10.62	88.11	5.56
Equal— B	41	20.04	29.88	9.36	89.46	3.13
Reduc.—B	38	19.61	31.46	9.92	86.50	6.32
Equal—A, B	83	19.63	31.31	9.55	88.93	4.06
Reduc—A, B	74	19.98	31.44	10.27	87.30	5.94

From the above table we have the following summary of results for average gross gain in the number of problems correctly added:

Sections	*Equal* Group	*Reducing* Group	*Reducing/Equal*
A	9.74	10.62	1.09
B	9.36	9.92	1.06
A, B	9.55	10.27	1.075

From the two comparisons of the A and B sections of the two groups, we have, as an average, *Reducing/Equal*, 1.075, which has a P. E. *t.—obt. Av.* of .0073. There is thus about one chance in a hundred thousand or so that the results from an extended series of similar experiments would show no advantage for the *Reducing* group. The chances are about ninety-nine to one that the ratio will be between 1.046 and 1.104.

Performing a similar operation with the data for the gain in per cent of problems correct, we have the following results:

Sections	*Equal* Group	*Reducing* Group	*Reducing/Equal*
A	5.00	5.56	1.10
B	3.13	6.32	2.02
A, B	4.07	5.94	1.47

Comparing the A and B sections of the two groups, we have, as an average, *Reducing/Equal*, 1.56, which has a P. E. *t.—obt. Av.* of .022. This means that in an extended series of similar experiments the *Reducing* group would practically always show the greater gain in the per cent of problems correct.

Taking as a basis of comparison, the median gross gain in the number of problems correct (*cf.* Table XXIII), fifty-six per cent of the *Reducing* group equal or exceed the median improvement made by the *Equal* group.

The *factors conditioning improvement* in this experiment were, in general, the same as those conditioning the improvement made by school children in the two larger experiments. So far as affecting one group more than the other is concerned, none of these factors need be discussed here, except the following:

The length of the practice-periods. Section A of the *Equal* group had, in all, six practice-periods of 10 minutes each. Section B of this group had an initial test of 10 minutes, then 8 periods of 5 minutes each, with a 10-minute period at the close. Section A of the *Reducing* group had an initial and final practice of 10 minutes each, with the intervening 40 minutes distributed in 5 periods as follows: 15, 10, 7½, 5, and 2½ minutes. The B section of this group had the same number of periods and of corresponding lengths, but the order of occurrence was *increasing* instead of *decreasing*, i. e., as follows: initial practice of 10 minutes, then 2½, 5, 7½, 10, and 15 minutes, with a final practice of 10 minutes.

According to the results the A section of each group made more gain than the B section of the same group. In each case, however, the sections of the *Reducing* group made more gain than the corresponding sections of the *Equal* group, roughly speaking, about one-tenth more.

The number of practice-periods. The A section of the *Equal* group had one *less* practice-period than the A section of the *Reducing* group. The B section of the *Equal* group had three more practice-periods than had the B section of the *Reducing* group. Roughly speaking, the average length of the practice-periods for the *Equal* group was 7½ minutes, that for the *Reducing* group 8⅓ minutes. If the *Reducing* group suffered by the reverse arrangement of the schedule for the B section, the *Equal* group appeared to suffer also by the five-minute periods of its B section.

In all other respects, such as the total length of time covered, the time-interval between periods, recency of last practice before the final test, etc., both groups were equally favored.

SECTION V

SUMMARY OF RESULTS OF ALL THE EXPERIMENTS

The essential facts concerning initial score and gross gain in the number of problems solved correctly, for all our experiments, are summarized in Table XXIV. Since, in general, the *Equal* and *Reducing* groups are about equal in initial ability, we may utilize the results shown in this table for a rough measure of the relative advantage of the two schedules as follows:

Using the last three columns, we have, as an average *Reducing/Equal*, 1.096, which has a P. E. *t.—obt. Av.* of .022. There are thus about two chances in a thousand that the results from an extended series of similar experiments would show no advantage for the *Reducing* schedule. The chances are even that the ratio will range between 1.07 and 1.12. Or, we may say, the chances are about four to one that the ratio will lie between 1.05 and 1.14; or, about nine to one that it will lie between 1.03 and 1.16; or, again we may say, the chances are about ninety-nine to one that in an extended series of similar experiments the ratio will fall between 1.01 and 1.18, and in only two cases out of a thousand would the ratio be 1.00, or less (i. e., in favor of the *Equal* schedule).

If, however, instead of using the rough data given in Table XXIV, we use that obtained by equalizing the two groups in respect to initial ability, we have slightly different results. These data are given in Table XXV. From this table we obtain as an average *Reducing/Equal*, 1.125. The P. E. *t.—obt. Av.* of this average is .033. There are thus about ten chances in a thousand that the results from an extended series of similar experiments would show no advantage for the *Reducing* group. The chances are even that the ratio will be between 1.09 and 1.16 or, we may say, the chances are about ninety-six to four that it will not exceed the limits of 1.03 and 1.22.

If the *Equal* and *Reducing* groups are compared in respect to the gain in per cent of problems correct, it is found that the latter group surely did better. The facts appear in Table XXVI. From the last

three columns of this table we have as an average *Reducing/Equal*, 2.64, which yields a P. E. *t.—obt. Av.* of .371. There are thus about three chances out of a thousand that in an extended series of similar experiments the *Reducing* schedule would show no advantage. The possible significance of the results of a similar treatment based on corrected data, after equalizing the two groups in respect to initial ability, would hardly warrant the labor of making the calculation. It could not notably alter the general results obtained from Table XXVI.

TABLE XXIV

SUMMARY OF AVERAGE INITIAL SCORE AND AVERAGE GROSS GAIN IN NUMBER OF PROBLEMS SOLVED CORRECTLY BY THE *Equal* AND *Reducing* GROUPS, IN ALL THE EXPERIMENTS

Place	Subjects	Material Used	Initial Score		Gross Gain		*Reduc./ Equal* (Gain)
			Eq. Gp.	Re. Gp.	Eq. Gp.	Re. Gp.	
T. C.	Adults	French	00.00	00.00	110.00	111.70	1.02
Lynd.	7th Gr.	Geog.	29.89	30.67	40.84	48.86	1.20
Lynd.	6th Gr.	Geog.	45.50	37.74	21.15	24.29	1.15
Lynd.	6th Gr.	Hist.	31.10	39.52	8.47[1]	40.25	(4.75?)
Lynd.	3rd, 4th Gr.	Add.	12.69	11.25	6.07	6.10	1.00
Lynd.	5th Gr.	Div.	65.98	70.04	64.66	71.42	1.10
Ohio	8th Gr.	Geog.	21.65	24.25	53.02	48.57	.92
Ohio	7th Gr.	Hist.	16.52	17.34	34.48	32.70	.95
Ohio	6th Gr.	Hist.	11.66	15.91	28.07	35.22	1.25
Lynd.	5th Gr.	Geog.	14.74	9.96	24.90	28.63	1.15
Ohio	3rd, 4th Gr.	Add.	8.90	9.47	5.70	7.07	1.24
B.G.N.C.	Adults	Add.	31.31	31.44	9.55	10.27	1.08

Ave. *Reducing/Equal* 1.096
S. D. *dis.* 108
P. E. *t.* —*obt. Av.* 022

[1] On account of special disturbances influencing this group, the data are omitted from the final calculations.

TABLE XXV

SUMMARY OF AVERAGE INITIAL SCORE AND AVERAGE GROSS GAIN IN NUMBER OF PROBLEMS SOLVED CORRECTLY, AFTER EQUALIZING THE INITIAL SCORES OF THE TWO GROUPS BY THE METHOD OF "PAIRING OFF" THE SCORES MADE BY ONE GROUP WITH THOSE MADE BY THE OTHER GROUP

Place	Subjects	Material Used	Initial Score		Gross Gain		*Reduc./ Equal* (Gain)
			Eq. Gp.	Re. Gp.	Eq. Gp.	Re. Gp.	
T. C.	Adults	French	00.00	00.00	110.00	111.70	1.02
Lynd.	7th Gr.	Geog.	30.77	30.76	41.96	47.11	1.12
Lynd.	6th Gr.	Geog.	43.04	42.88	19.54	29.24	1.50
Lynd.	6th Gr.	Hist.	34.26	34.18	9.13[2]	38.77	(4.24?)
Lynd.	3rd, 4th Gr.	Add.	12.05	12.02	6.02	6.25	1.04
Lynd.	5th Gr.	Div.	68.01	67.73	68.18	69.88	1.03
Ohio	8th Gr.	Geog.	21.65	21.75	53.02	50.23	.95
Ohio	7th Gr.	Hist.	16.52	16.51	34.48	32.78	.95
Ohio	6th Gr.	Hist.	12.07	12.44	28.86	35.60	1.23
Ohio	5th Gr.	Geog.	10.25	9.96	21.35	28.63	1.34
Ohio	3rd, 4th Gr.	Add.	8.90	8.87	5.70	6.34	1.11
B.G.N.C.	Adults	Add.	31.31	31.44	9.55	10.27	1.08

Ave. *Reducing/Equal* 1.125 S. D. *dis.* .164 P. E. *t.—obt. Av.* .033

TABLE XXVI

SUMMARY OF FACTS CONCERNING AVERAGE GAIN IN ACCURACY, FOR BOTH GROUPS IN ALL THE EXPERIMENTS

Place	Subjects	Material Used	Initial per Cent Correct		Gain in per Cent Correct		*Reduc./ Equal* (Gain)
			Eq. Gp.	Re. Gp.	Eq. Gp.	Re. Gp.	
Lynd.	7th Gr.	Geog.	77.55	74.88	1.44	8.91	6.19
Lynd.	6th Gr.	Geog.	76.74	72.72	.47	1.54	3.28
Lynd.	6th Gr.	Hist.	72.67	77.26	.87[2]	3.42	(3.93?)
Lynd.	3rd, 4th Gr.	Add.	59.86	52.92	−1.27[3]	6.94	5.46?
Lynd.	5th Gr.	Div.	87.54	85.00	6.57	7.86	1.20
Ohio	8th Gr.	Geog.	65.77	65.20	29.38	25.85	.88
Ohio	7th Gr.	Hist.	65.67	62.98	12.56	32.68	2.60
Ohio	6th Gr.	Hist.	67.15	69.55	16.27	22.00	1.35
Ohio	5th Gr.	Geog.	57.93	45.81	14.14	34.82	2.46
Ohio	3rd, 4th Gr.	Add.	43.28	45.85	5.90	8.95	1.52
B.G.N.C.	Adults	Add.	88.93	87.30	4.06	5.94	1.46

Ave. *Reducing/Equal* 2.64 S. D. *dis.* 1.74 P. E. *t.—obt. Av.* .371

[2] On account of special disturbances influencing this group, the data are omitted from the final calculations.

[3] Our conclusions are only rendered more conservative by treating this negative gain as though it were positive.

The final result is thus an advantage of five to fifteen per cent in favor of practice distinguished chiefly by decreasing period-lengths and increasing intervals, but also by other differences. Until the effect of these other factors has been more fully studied the psychology of the results obtained here remains somewhat obscure. For educational practice the outstanding fact is that the same amount of time gave notably better results when distributed according to the *Reducing* schedule than when distributed evenly.

CHAPTER VI

THE AMOUNT OF IMPROVEMENT AND ITS RELATION TO INITIAL ABILITY

THE AMOUNT OF GROSS GAIN

In respect to amount of gain made, our results, in general, support the conclusions already drawn from similar experiments by Thorndike, Kirby, Chapman, and others, in that a very great amount of gain is shown from a relatively small amount of practice. Comparatively speaking, however, the amount of gain made by our subjects was considerably less than that reported by the above-named authors. The following figures show the comparison between certain of the results published by Dr. Kirby and certain of our own results.

ROUGH COMPARISON OF AMOUNT OF GAIN MADE BY SOME OF OUR OWN SUBJECTS AND THE SUBJECTS USED BY KIRBY

Investigator	No. of Pupils	Grade	Material Used	Amount of Practice Measured in Terms of Minutes	Ave. No. of Problems Solved Correctly per Min. in the Init. Test	Ave. Gross Gain in No. of Problems Solved Correctly per Minute
Kirby	732	4th	Add.	60	1.7	.7
Cummins	266	4th	Add.	100	1.0	.5
Kirby	606	3rd, 4th	Div.	50	3.4	2.8
Cummins	171	4th, 5th	Div.	100	3.1	2.9

The amount of gain here shown is approximately 50 to 100 per cent on the initial score. That which is least expected, however, is that our subjects, working under ordinary school conditions similar to those reported by Kirby, and using identical material, made less gain in 100 minutes of practice than his pupils made in 60 minutes.

Of course, no one would expect that any group of pupils would keep up so rapid a rate of improvement for any great length of time, probably not for, say, 1,000 minutes, and possibly not for 500 minutes. Our own results tend to show, however, that the limit of rapid improvement had not yet been reached with 100 minutes of practice. The figures below give, for certain of our subjects, the rate of improvement for the first 80 minutes of practice and the rate for the concluding 35 minutes, on the basis of the number of problems solved in 15 minutes.

Number of Pupils	Grade	Material	Ave. No. of Problems Correct in Initial Test	Ave. No. of Problems Correct in Intermediate Test	Ave. No. of Problems Correct in Final Test
153	3, 4	Add.	10.25	15.73	17.35
71	5	Div.	70.04	102.92	141.46

From the above figures we have, in the case of the third and fourth grade pupils, an average gain, in the number of problems solved correctly in fifteen minutes, of .34 of a problem for every five minutes of practice from the initial test to the intermediate test, i. e., the first eighty minutes of practice. The average gain for the next thirty-five minutes, i. e., up to the final test, was .23 of a problem for every five minutes of practice. In the case of the fifth grade pupils, the results show a very decided increase for the last thirty-five minutes of practice. The rate of increase for every five minutes of the first eighty minutes of practice was 2.06 problems, while for the remaining thirty-five minutes it was 5.51 problems for every five minutes spent in practice.

In the case of our subjects who learned geography and history the amount of gain appears even greater than in the case of the subjects just reported upon. The great amount of gain made was probably due (1) to the fact that the bonds exercised were newer, (2) to the nature of the material used, and (3) to the method of scoring used, all of which have already been discussed in previous sections.

INITIAL SCORE AND GROSS GAIN

The assumption set forth in previous sections, viz., that gross gain is positively correlated with initial score, is borne out by all our results. Tables XXVII, XXVIII, XXIX, and XXX exhibit the facts in a way that requires little comment.

These tables are not really suitable for calculating correlation coefficients, but in order to get a notion of the relation comparable with other relations, I have computed the correlations by the method of unlike-signed pairs, which gives the following coefficients:

Material Used	No. of Pupils	Grades	Correlation between Initial Score and Gross Gain
Geography	421	5, 6, 7, 8,	.13
History	312	6, 7	.06
Addition	579	3, 4	.16
Division	171	4, 5	.64

By a further grouping of the frequencies contained in the four tables, we have the results in the form shown in Table XXXI. A comparison of the *low-initial-score* group in each case with the *high-initial-score* group shows roughly the amount of correlation between initial score and amount of gain. The exceedingly high correlation shown in the case of the fourth and fifth grade pupils, who practised short division, is a fact which deserves further investigation.

TABLE XXVII

AMOUNT OF IMPROVEMENT IN RELATION TO INITIAL SCORE, IN THE CASE OF 421 5TH, 6TH, 7TH, AND 8TH GRADE PUPILS WHO LEARNED GEOGRAPHICAL FACTS

The table reads as follows: Of the 19 pupils with an initial score of 0, 1, 2, 3, or 4, there were none who made an improvement of less than 0; 5 made an improvement of from 0 to 9; 4 from 10 to 19; etc.

Amount of Improvement in Number of Words Supplied

Init. Score	Less than 0	0 9	10 19	20 29	30 39	40 49	50 59	60 69	70 79	80 up	
0– 4	..	5	4	3	2	1	2	1	1	..	19
5– 9	3	7	6	14	7	5	1	..	1	1	45
10–14	1	5	8	11	12	12	3	2	..	..	54
15–19	1	1	4	7	6	6	6	2	1	1	*35*
20–24	1	..	4	8	8	7	14	5	2	2	*51*
25–29	1	4	4	8	10	10	4	4	3	6	*55*
30–34	..	3	7	9	6	15	6	3	3	3	55
35–39	1	1	3	6	10	8	6	..	2	2	39
40–44	..	3	4	3	5	3	4	3	1	1	*27*
45–49	..	..	4	3	5	..	3	..	1	1	*17*
50–54	..	..	3	3	5	..	2	1	..	1	*15*
55–59	..	..	..	2	2	1	..	..	..	..	*5*
60–up	..	1	1	1	..	..	1	..	..	..	*4*
	8	*30*	*52*	*78*	*78*	*68*	*53*	*21*	*15*	*18*	*421*

TABLE XXVIII

AMOUNT OF IMPROVEMENT IN RELATION TO INITIAL SCORE, IN THE CASE OF 312 6TH AND 7TH GRADE PUPILS WHO LEARNED HISTORICAL FACTS

(*This table reads the same as Table XXVII*)

Amount of Improvement in Number of Words Supplied

Init. Score	Less than 0	0 9	10 19	20 29	30 39	40 49	50 59	60 up	
0– 4	1	..	4	5	2	4	..	..	*16*
5– 9	..	1	9	13	7	7	6	1	*44*
10–14	2	1	8	14	13	19	8	1	*66*
15–19	..	6	5	10	15	19	8	1	*64*
20–24	3	1	3	4	10	7	5	2	*35*
25–29	2	4	4	1	11	6	..	..	*28*
30–34	2	3	4	..	9	1	2	1	*22*
35–39	1	..	1	1	3	5	..	1	*12*
40–44	1	2	..	1	3	..	3	..	*10*
45–49	..	..	2	1	1	..	..	..	*4*
50–54	..	..	1	..	..	3	1	1	*6*
55–59	..	..	1	..	1	1	..	..	*3*
60–up	..	..	..	..	..	1	1	..	*2*
	12	*18*	*42*	*50*	*75*	*73*	*34*	*8*	*312*

TABLE XXIX

AMOUNT OF IMPROVEMENT IN RELATION TO INITIAL SCORE, IN THE CASE OF 579 3RD AND 4TH GRADE PUPILS WHO PRACTISED SINGLE-COLUMN ADDITION

(*This table reads the same as Table XXVII*)

Amount of Improvement in the Number of Problems Added Correctly

Init. Score	Less than −11	−10 −6	−5 −1	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 up	
0– 4	..	..	19	69	33	8	8	6	..	2	1	*146*
5– 9	..	3	29	30	26	25	13	6	1	..	1	*134*
10–14	..	13	22	46	22	14	9	7	3	..	1	*137*
15–19	4	6	19	17	14	10	5	4	3	1	..	*83*
20–24	1	6	6	10	12	3	4	..	..	3	1	*46*
25–29	1	3	3	1	2	4	1	..	1	..	1	*17*
30–34	2	..	2	2	..	2	..	1	..	..	1	*10*
35–up	..	..	..	..	1	2	..	1	..	..	2	*6*
	8	*31*	*100*	*175*	*110*	*68*	*40*	*25*	*8*	*6*	*8*	*579*

TABLE XXX

AMOUNT OF IMPROVEMENT IN RELATION TO INITIAL SCORE, IN THE CASE OF 171 4TH AND 5TH GRADE PUPILS WHO PRACTISED SHORT DIVISION

(*This table reads the same as Table XXVII*)

Amount of Improvement in Number of Problems Solved Correctly

Init. Score	Less than 0	0 9	10 19	20 29	30 39	40 49	50 59	60 69	70 79	80 89	90 99	100 119	120 up	
0– 9	1	4	6	2	..	..	..	1	..	..	..	..	..	*14*
10–19	..	2	1	7	3	1	..	1	1	..	1	..	..	*17*
20–29	1	1	1	3	1	3	4	2	..	1	..	..	..	*17*
30–39	..	..	1	3	5	3	1	2	1	..	..	1	..	*17*
40–49	1	..	1	1	3	1	..	3	2	1	1	..	1	*15*
50–59	..	..	..	1	1	2	2	2	2	3	2	2	..	*17*
60–69	..	..	..	2	..	3	..	..	6	2	2	1	2	*18*
70–79	..	..	..	..	3	..	3	2	2	1	..	..	1	*12*
80–89	1	1	1	..	..	2	1	1	3	..	1	..	1	*12*
90–99	..	..	..	..	..	..	3	..	2	..	..	1	1	*7*
100–119	..	..	1	..	..	2	1	..	1	1	..	2	4	*12*
120–139	1	..	..	..	..	..	2	..	..	..	1	3	3	*8*
140–up	..	..	..	..	..	..	..	1	..	..	..	2	2	*5*
	5	*8*	*12*	*19*	*16*	*17*	*17*	*15*	*20*	*9*	*8*	*10*	*15*	*171*

TABLE XXXI

CONDENSATION OF TABLES XXVII, XXVIII, XXIX, AND XXX WITH THE MEDIANS INSERTED FOR EACH GROUP

5th, 6th, 7th, and 8th Grade Pupils (Geography)

	Less than 0	0 9	10 19	20 29	30 39	40 49	50 59	60 69	70 79	80 up	*Total*	Median
0–14	4	17	18	28	21	18	6	3	2	1	*118*	27.14
15–24	2	1	8	15	14	13	20	7	3	3	*86*	42.31
25–34	1	7	11	17	16	25	11	7	6	9	*110*	41.20
35–up	1	5	15	18	27	12	16	4	4	5	*107*	35.37
	8	*30*	*52*	*78*	*78*	*68*	*53*	*21*	*15*	*18*	*421*	

6th and 7th Grade Pupils (History)

	Less than 0	0 9	10 10	20 29	30 39	40 49	50 59	60 up	*Total*	Median
0– 9	1	1	13	18	9	11	6	1	*60*	28.33
10–14	2	1	8	14	13	19	8	1	*66*	36.15
15–24	5	11	12	15	36	32	13	3	*127*	35.69
25–up	4	5	9	3	17	11	7	3	*59*	32.06
	12	*18*	*42*	*50*	*75*	*73*	*34*	*8*	*312*	

3rd and 4th Grade Pupils (Addition)

	Less than —11	—10 —6	—5 —1	0 4	5 9	10 14	15 19	20 24	25 29	30 34	35 up	*Total*	Median
0– 4	..	..	19	69	33	8	8	6	..	2	1	*146*	3.91
5– 9	..	3	29	30	26	25	13	6	1	..	1	*134*	5.96
10–14	..	13	22	46	22	14	9	7	3	..	1	*137*	3.64
15–up	8	15	30	30	29	21	10	6	4	4	5	*162*	4.67
	8	*31*	*100*	*175*	*110*	*68*	*40*	*25*	*8*	*6*	*8*	*579*	

4th and 5th Grade Pupils (Division)

	Less than 0	0 9	10 19	20 29	30 39	40 49	50 59	60 69	70 79	80 89	90 99	100 119	120 up	*Total*	Median
0–29	2	7	8	12	4	4	4	4	1	1	1	..	..	*48*	25.83
30–49	1	..	2	4	8	5	1	5	3	1	1	1	1	*32*	42.00
50–79	..	..	..	3	4	4	5	4	10	6	4	3	3	*47*	73.50
80–up	2	1	2	..	..	4	7	2	6	1	2	6	11	*44*	76.67
	5	*8*	*12*	*19*	*16*	*17*	*17*	*15*	*20*	*9*	*8*	*10*	*15*	*171*	

VITA

ROBERT ALEXANDER CUMMINS. Born, Pope County, Illinois, 1874.

EDUCATIONAL

1905–1909, Illinois Wesleyan University, B.S.
1909–1910, University of Illinois, M.A., in Education.
1912–1914, Part-time student, University of Washington, University Life Diploma in Education.
1914–1915, 1917–1918, Teachers College, Columbia University.

Graduate of Valparaiso, Indiana, Business Institute, followed by seven years' experience in business positions, as shipping clerk, bookkeeper, head office man and assistant manager for manufacturing concerns prior to entering college in 1905.

PROFESSIONAL

1906–1907, Assistant in Biology, Illinois Wesleyan University.
1907–1908, Assistant in Physics.
1908–1909, Assistant in Commercial Department and Director of the Chapel Choir.
1910–1913, Professor of Philosophy and Education and Head of Normal Department, University of Puget Sound.
1912, Professor of Theory and Practice, Tacoma Summer Normal.
1913, Assistant Professor of Psychology, University of Washington, Summer Session.
1913–1914, Instructor in Psychology, University of Wāshington.
1915–1917, Professor of Psychology and Education, Bowling Green, Ohio, State Normal College. (Extension teaching thirty weeks of year and Intra-mural, spring and summer terms.)
1918, Statistical Psychologist (part-time), Ethical Culture School, New York City.
1918, Head of Department of Education, Simpson College, Indianola, Iowa.

HONORS RECEIVED

Member of College Debating Team, four years, Illinois Wesleyan University.
Graduate Scholar, University of Illinois, 1909–1910.
Charter Member, University of Washington, Nu Chapter, Phi Delta Kappa, 1913.
Graduate Research Scholar, Teachers College, Columbia University, 1914–1915.
Graduate Scholar, Teachers College, Columbia University, 1917–1918.

PREVIOUS PUBLICATIONS

"A Study of the Effect of Basket Ball Practice on Motor Reaction, Attention and Suggestibility," *Psychological Review*, Vol. XXI, No. 5, September, 1914.
"A Study of Defective Pupils in the Public Schools of Tacoma, Washington," *The Psychological Clinic*, Vol. VIII, No. 6, November 15, 1914.
"The Functions and Relations of Rural Supervisors," *American School Board Journal*, February, 1917.
"Individual Differences in a Normal School Class," *The Psychological Review*, Vol. XXIV, No. 5, September, 1917.
"A Health Survey in a Small City System," *American School Board Journal*, November, 1917.
"A Psychological and Health Survey of the Van Wert Public Schools," published by the Board of Education, Van Wert, Ohio, 1918.
Numerous articles on Pedagogy, in state teachers' journals of Washington and Ohio; also articles on Religious Pedagogy, in church periodicals.